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In this issue:

APPLICATION *of*
STROWGER AUTOMATIC TOLL TICKETING
and
PUNCH CARD TOLL ACCOUNTING
in
METROPOLITAN TELEPHONE NETWORKS

By

J. T. NAYLOR, General Manager

SUNLAND-TUJUNGA TELEPHONE COMPANY

LOS ANGELES, CALIFORNIA

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About the Author

JOHN THOMAS NAYLOR is a graduate of Oregon State College (B.S. in E.E. '34), and has been engaged in engineering, accounting, and administrative capacities in the public communications field since 1938, when he was appointed engineer for the Telephone and Telegraph Division of the Public Utilities Commission of Oregon. He entered the Independent telephone industry in 1941, when he accepted a position as telephone engineer with Associated Telephone Company, Limited, Santa Monica, Calif., later becoming vice president. During his association with that company, he was engaged in a wide variety of operating and administrative activities, embracing technical and legal investigations, regulatory matters, and operating and settlement practices involving neighboring companies.

Early in 1946, Mr. Naylor left the Associated company to take over the administration of the Sunland-Tujunga Telephone Company, one of the several large Independent companies operating in the Los Angeles metropolitan area. Special training in accounting, added to his broad experience in engineering, regulation, and commercial matters, had provided him with a background well suited to duties involved in the administration of this rapidly growing company, and particularly to study of the complex problems relating to the handling of inter-community toll traffic in that area.

Mr. Naylor has long been active in various capacities with both local and national telephone associations. Since 1942, he has been chairman of Pacific Coast Telephone Committee on Inter-Company Settlements; since 1946 chairman of the Pacific Coast Rural Telephone Service Committee; and since 1943 a member of the Toll Compensation and Settlements Committee of the United States Independent Telephone Association. He is a member of the American Institute of Electrical Engineers, and is registered as a professional engineer in the states of California, Oregon, Washington and Oklahoma. He has become widely known throughout the industry for his work on these bodies and also as a contributor to various trade journals of articles on technical and accounting matters.

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FOREWORD

AMONG the developments in automatic telephone switching which have taken place during the past ten or fifteen years, few have stirred the interest of telephone engineers and operating executives as much as the techniques which are now being put to use in metropolitan exchange areas for subscriber dialing of short-haul toll calls.

The rapidly growing volume of toll traffic in such areas, and the steadily increasing cost of handling such volume at high speed by conventional manual methods, long ago suggested the need for extending to it the benefits of automatic switching under subscriber dial control. Recent years have seen the rapid development of techniques in this direction. Such extension of automatic switching inevitably involves the automatic timing and recording of toll calls as a prerequisite for billing subscribers, as well as the need for fitting the toll ticket records into the particular billing and accounting procedures which the operating company may find best suited to its needs.

Among Independent telephone companies, the methods so far employed for subscriber toll dialing are based on adaptations of Strowger Automatic switching principles, the whole system being commonly referred to as the Strowger Automatic Toll Ticketing (SATT) System.

In this article, Mr. Naylor reviews the factors which led to the adoption of Strowger Automatic Toll Ticketing in the Sunland exchange, and gives a comprehensive description of the methods employed and apparatus used for subscriber dialing of calls into other exchanges in the Los Angeles metropolitan area, with particular emphasis on the commercial and economic factors which may influence the choice between various procedures. The article also includes a discussion of the means whereby toll ticketing records in the Sunland exchange are fitted into the Company's automatic punch card billing and accounting procedures.

Mr. Naylor's close association with the applications he describes and the comprehensive scope of his discussion make his article an authoritative document of first importance among current telephone literature. We are glad to take this means of extending our thanks to him for the opportunity of devoting this special issue of *The Automatic Electric Technical Journal* to making it a matter of permanent record for the benefit of the industry.

The Editor

APPLICATION of
STROWGER AUTOMATIC TOLL TICKETING
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in
METROPOLITAN TELEPHONE NETWORKS

By J. T. NAYLOR, *General Manager*
Sunland-Tujunga Telephone Company
Los Angeles, California

Introduction

The scope and subject of this article contemplate the mechanization of all of the operations necessary to measure telephone usage and collect the charges therefor from the moment a telephone user lifts his receiver to place a short-haul toll call until he receives and pays his printed monthly bill. The completion of short-haul toll calls is accomplished by direct subscriber dialing from one exchange to another without interposing an operator or manual switchboard attendance. The following functions are handled automatically:

1. Recording the calling party's telephone number.

2. Recording the called party's telephone number.

3. Recording the date and clock time of terminating each telephone call.

4. Recording the total elapsed conversation time for each telephone call.

5. Recording the class (local or extended) of telephone subscriber placing each telephone call.

6. Recording the distance or rate zones spanned by each telephone call.

7. Recording the rates and charges applicable to each telephone call.

8. Sorting call records or "tickets" by calling telephone number for billing purposes.

9. Listing individual telephone calls by date, called number and charges on individual customer statements.

10. Summing up total long distance charges on customer toll statements for billing.

11. Setting up accounting controls for the accumulation and checking of all customer toll statements for each billing period.

12. Recording collection results against billed amounts for individual subscribers.

Various practical devices such as calculagraphs, direct operator dialing circuits and sundry accounting machines have successfully displaced manpower in conducting certain isolated features of the procedures listed above. Complete mechanization of the entire list of functions in a coordinated and systematized plan even to the extent of eliminating switchboard operating personnel, typists and adding machine operators was achieved for the first time in January, 1950, in the "FLorida" Exchange of Los Angeles, California, operated by the Sunland-Tujunga Telephone Company.

The historical background for technical progress which has led to the Los Angeles installation dates back to 1889 when Almon B. Strowger in-

vented in Kansas City the first switch capable of completing telephone connections without manual switchboard attendance, and back to November 3, 1892, when the first automatic, local telephone exchange rendering telephone service to the public was placed in operation at La Porte, Indiana. From those dates until the early 1920's the improvement and expansion of automatic telephone service in local exchanges on unlimited, free-calling traffic kept pace with a rapidly growing public demand for more and more telephone communication.

In 1928, after several years of research, a patent was issued for a scheme whereby a subscriber wishing to call another subscriber located in a separate community could dial a code to reach a circuit to the distant community and at the same time activate registration apparatus registering the calling subscriber's number and permitting him then to dial directly to the distant subscriber. This device employed a pen register to record the called party's number and the elapsed time of conversation. This early development was not applied commercially but became a forerunner of the establishment in Belgium in the middle 1930's of direct subscriber toll dialing from individual line stations throughout Belgium. By 1937, a successful installation was made in the city of Mons, Belgium in which the information required for billing purposes was all printed on a standard toll ticket and showed the calling party's number, the called zone, the called party's number, the date and time of placing the call, the total elapsed time, the rate applicable and the total computed charge for the call. Mr. John E. Ostline, System Development Engineer, Automatic Electric Company, Chicago and Fellow of the American Institute of Electrical Engineers invented and developed some of these early systems and through his continuing enterprise and the research policies of his company the perfected commercial grade of toll ticketing installed at Sunland has resulted. Mr. R. Stehlik, Chief Engineer, Automatique Electrique, S.A., Antwerp, Belgium and his firm were principal contributors to the success of the systems installed for the Belgium Communications Administration.

Upon completion of these systems in Belgium, work was initiated by Automatic Electric Company delegating to Mr. Ostline's direction the adaptation of automatic toll recording operations to short haul toll calling volumes in large metropolitan areas of the United States. Bell Telephone Laboratories and Western Electric Company were working toward the same objective and on January 16, 1944, Automatic Toll Recording operations were begun in the Culver City Exchange of The Pacific Telephone and Telegraph Company in Los Angeles, California. In the same year an experimental test installation piloting the Sunland type of automatic ticketing equipment was placed in operation on a limited, non-commercial scale on premises of Associated Telephone Company, Ltd. of Santa Monica, California.

Until completion of the Sunland (Los Angeles "FLorida" Exchange) office toll recording installation the automatic recording features were confined to use on single party and two-party lines, being incapable of identifying calling party numbers on lines having more than two subscribers and thereby being restricted to serving only the very high grade development and demanding acceptance of these more expensive services to obtain the direct dialing feature on short haul toll traffic. The "FLorida" Exchange installation makes the service available to four-party development as well as to the one and two-party development, thus expanding the service to include the most economical grades of metropolitan communication offered by telephone public utilities. The Sunland installation, while being the first to offer the complete service to all subscribers and in addition having certain unique and advantageous features which will be discussed in subsequent sections of this paper, will be the twelfth such commercial installation of automatic toll ticketing operation in the Los Angeles Metropolitan Area having been preceded by installations in Culver City (January 1944), Beverly Hills (March 1948), Hawthorne (July 1948), Los Angeles "Richmond" (July 1948), Alhambra "Main" and "San Gabriel" (September 1948), Montebello (October 1948), Inglewood (December 1948), Van Nuys "Cedros" (May 1949), Van Nuys "Kester" (June 1949) and Pasadena "Lake" (August 1949).

As is invariably true of new developments having general commercial acceptance, *need* for automatic toll ticketing preceded, or at least developed in pace with, the ability of engineers to design the equipment and circuits required. The growth of metropolitan areas and the merging into one vast

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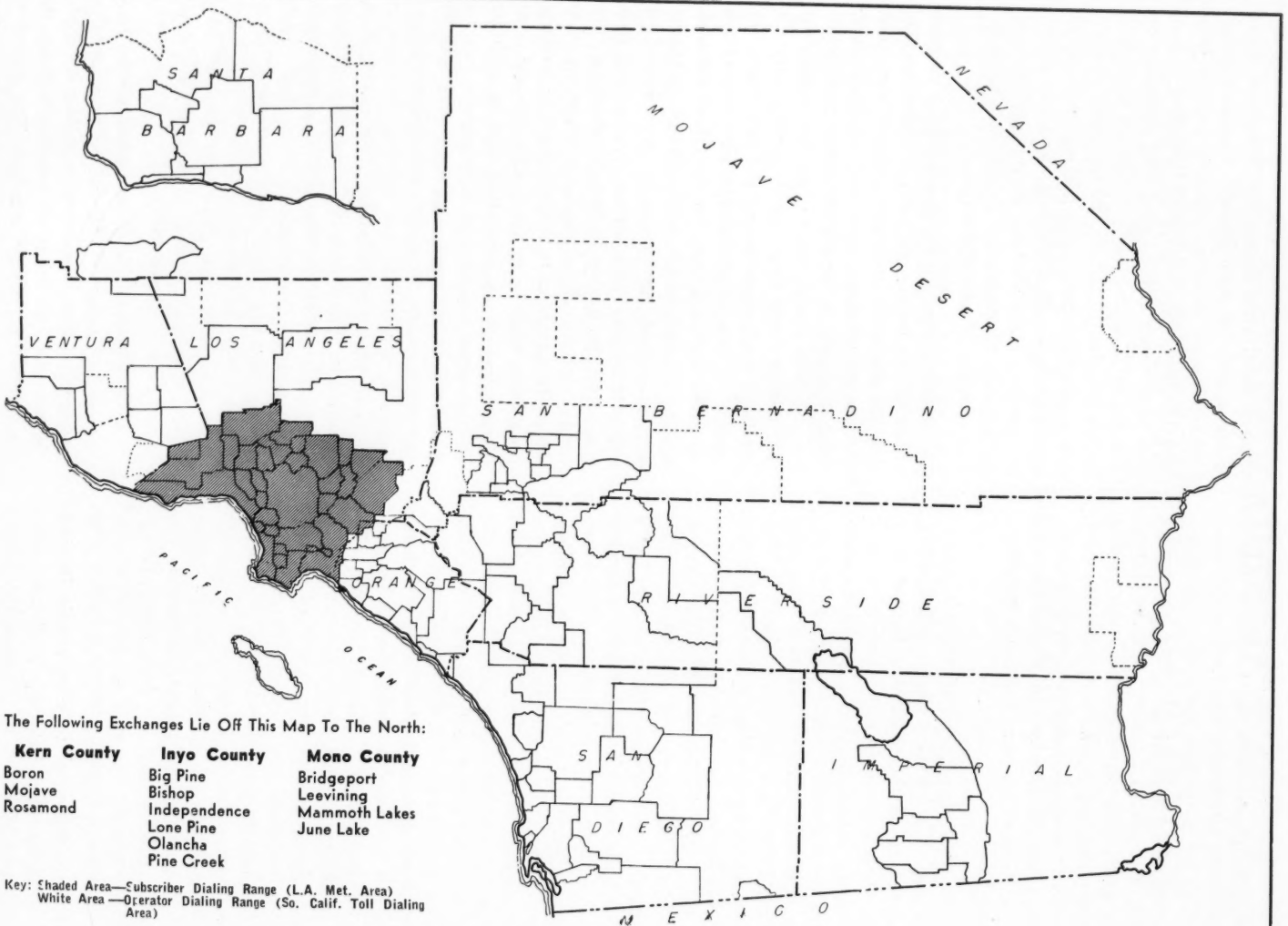

The Following Exchanges Lie Off This Map To The North:

Kern County	Inyo County	Mono County
Boron	Big Pine	Bridgeport
Mojave	Bishop	Leevining
Rosamond	Independence	Mammoth Lakes
	Lone Pine	June Lake
	Olancha	
	Pine Creek	

Key: Shaded Area—Subscriber Dialing Range (L.A. Met. Area)
White Area —Operator Dialing Range (So. Calif. Toll Dialing Area)

Figure 1. Southern California Toll Dialing Area.

community of numerous suburban towns is attended generally by the erasure of commercial, civic and physical boundaries including boundaries between "communities of interest" for telephone calling. A high volume of short haul toll calling develops and a demand is created for more rapid and unobstructed intercommunication between all segments of the metropolitan district. Both economic factors and customer requirements conspire to render obsolete established toll handling practices. The problems created for the telephone public utility in this regard are answered in part by the development of new commercial arrangements such as extended area rate plans, offering unlimited calling into certain limited areas contiguous to the original exchange. Charges for extended service are computed either at flat rates or at message count rates not involving timing of traffic, thus by-passing switchboards for much traffic and eliminating both the time and cost of making records on extremely low revenue message volume. As stated, however, this commercial medium supplies only a partial answer because the raising of flat or message rates on untimed traffic to cover required costs reaches a level of discrimination against low volume users and a level wherein the effect of diminishing returns is felt before a free-calling access to any appreciable percentage of the entire metropolitan area can be offered. Thus it has been found necessary, under the most carefully planned extended rate area commercial program, to handle great volumes of timed and ticketed messages having very low revenue per unit and entailing high operating costs when conducted manually by employed personnel. Further it is found that the expansion of extended area commercial plans tends to stimulate usage on all routes, including timed and ticketed toll routes, by reducing for the subscriber the concept of cost and measurement when using the telephone.

From the foregoing it will be appreciated that the stage setting for the introduction of Automatic Toll Switching and Accounting is comprised of (1) the telephone utility's objective of reducing to the minimum annual figure the cost of handling telephone traffic requiring ticketing, and (2) the telephone user's demand for maximum speed, fewer operator contacts and minimum cost in supplying his toll service. Subsequent sections of this article will be devoted to the analysis of individual ingredients of this problem and to the discussion of specific technological answers which have been found practical.

Toll Dialing

To accomplish direct subscriber dialing or operator dialing between exchanges it is necessary to establish a coordinated numbering plan having mutually exclusive routing digits for each of the accessible exchanges in the network, thus avoiding duplication of combinations of digits. The memory capacity of the human mind, unless specially trained for the purpose, establishes definite limitations on the number of digits usable in a single telephone number. These limitations have dictated a nation-wide, seven-digit numbering plan keyed to subscriber usage and untrained dialing operation and employing the association of two letters of the alphabet with five numerals to accomplish the completion of dialed calls. (Example MAin 3-2431). This universal, seven-digit numbering scheme will not be wholly achieved for some years in the future but other combinations of letters and numerals developed over some years of previous experience have confined the human error factor to acceptable maximums; the equipment and operations which are subject of this paper are generally capable of handling the deviations from this uniform plan during the interim of conversion. This will be explained more fully in the discussion of operational features of the central office equipment.

Each telephone office area number assignment contemplates a standard 10,000 terminal capacity, thereby reserving the last four digits of the telephone number for specific station identification (9,999 being the highest figure available using four numerals); thus it is practical in a seven-digit plan to reserve the first three digits (two letters and first numeral) for routing between offices. For example, in the number MAin 3-2431 the digits MA 3 identify the office area and the digits 2431 identify the specific telephone in the MA 3 office. Certain limitations upon the range of untrained subscriber dialing telephone usage are inherent in the design of the dial mechanism and the placing of dial markings. There are ten spaces or "dial pulls" on the standard dial, each containing one numeral; eight of these spaces (2 thru 9) also contain three letters each, and one letter (Z) is asso-

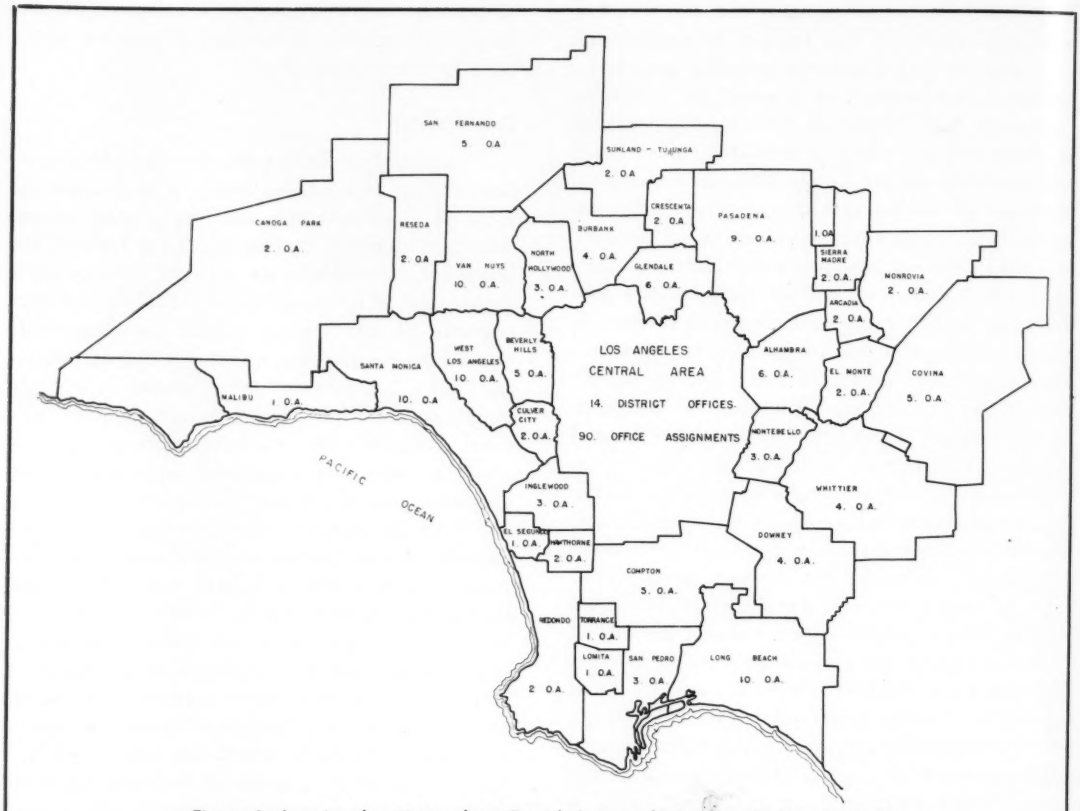

Figure 2. Los Angeles Metropolitan Extended Area. (Subscriber Dialing Range.) Letters "O.A." Stand for "Office Assignments".

ciated with the zero space. Theoretically this arrangement would permit a maximum of 640 three-digit (two letters and one numeral) routing combinations, but certain unpronounceable combinations of consonants preventing the development of a usable English language prefix name reduce the practical availability of three routing digit combinations to approximately 450 routing codes, (eliminating the use of "0" numeral in establishing codes and recognizing impractical prefix combinations such as "KJ", "LJ", "XZ", etc.) This limits the number of exchanges which may be included in any given coordinated subscriber dialing area to 450 offices.

Actually at the present time subscriber dialing is reduced further in range by the physical availability of trunk routes accessible from the subscriber's dial. Unless all of the exchanges in a given coordinated numbering area have either direct trunking circuits to each of the other exchanges in the area or a tandem trunking arrangement (routing via other intermediate offices), permitting direct dialing access throughout the entire area, it is physically impossible to reach all distant subscriber stations without imposing a switchboard and operator, where trunks from all offices converge and may be inter-connected. It is feasible that the ultimate availability of trunking throughout the various dialing areas in the country will permit direct subscriber access to all exchanges in each area, but, using the Southern California toll dialing area as one of the leading examples of trunking availability at the present time, a maximum of only 35 exchanges, most being multi-office exchanges, and approximately 225 office assignments are available in the Los Angeles Metropolitan Area (1¼

million telephones in 1950) out of a total of 146 exchanges (80 Bell System and 66 Independent) in the overall coordinated toll dialing area. Figure 1 illustrates the Southern California toll dialing area (about 49,000 square miles) and indicates the subscriber dialing range in the metropolitan area (1500 square miles, 50 miles across, 7 message units), this latter comprising the shaded section on the map. Figure 2 is an enlarged map of this subscriber dialing range. It is of course true that these 35 exchanges in the Los Angeles Metropolitan Area do contain one-half or more of the office assignments and seventy-eight per cent of the number of subscriber stations in the area.

Where lack of trunking and dialing limitations restrict the *subscriber* dialing range the preferable alternative becomes *operator* dialing wherein advantage may be taken of operator training procedures to increase the number of prefix digits (from 3 digits to 6 or more) usable successfully in routing between exchanges. Key-sending devices and special circuits which overcome the physical characteristics and the markings of the standard type of dial may also be added at a switchboard.

At the present time automatic toll switching and accounting procedures are applicable only to the range of *subscriber dialed* traffic. There is every reason to expect, however, that in the future the automatic toll accounting principles will be applied, at least in part, to operator dialing. Such possibilities will be discussed more fully in the concluding paragraphs of this paper.

Trunking Arrangements

There are three general types of telephone routing between exchanges: (1) routing via manual switchboard switching centers or "toll offices"; (2) direct subscriber dialing circuits between offices; and (3) tandem routing, or use of circuits routed via one or more other dial offices or dial switching points.

Manual switchboard toll offices are traditionally the established means of routing toll traffic. Circuits from each of many exchanges in a general area are brought in to a common point where they may be interconnected by a switchboard operator. In present plans for automatic toll accounting it has been the objective to confine the usage of these manual toll offices to that traffic falling within the *operator* dialing range and to eliminate all such offices for traffic within the *subscriber* dialing range where suitable automatic trunking can be provided.

Direct trunk routes in metropolitan areas are confined to short distances into contiguous offices where they serve to eliminate back hauls from toll offices or tandem switching points and where volumes of traffic permit efficient usage of these individual routes within an acceptable economic range. In complicated multi-office areas direct routing produces extravagance in outside physical plant when extended beyond a limited contiguous area. Tandem trunking under these circumstances offers the efficiency of single heavily developed routes switched on a central automatic basis.

Major economies and efficiency are achieved by locating tandem switching centers at strategic points in a metropolitan area. Providing for each exchange a single cable circuit group to reach a multiplicity of destinations permits averaging out calling volumes and absorbing the capricious peak loads on specific routes in a single calculation of trunking margin, and takes advantage of *total* calling volumes as contrasted to *piecemeal* calling volumes and traffic fluctuations on a direct routing basis. The expansion of tandem trunking throughout an entire toll dialing area involves transmission and traffic calculations which are not included in the scope of this article but the trend is in keeping with the principles previously cited of expanding subscriber dialing access as rapidly as calling volumes and economic factors will permit.

Figure 3 illustrates schematically the toll trunking scheme for the Sunland "FLorida" office, designating subscriber access from the "FLorida" office to the toll office, to direct trunking, and to tandem trunking.

Central Office and Subscriber Station Operating Features

Automatic toll accounting operation encompasses two separate and distinct departmental functions, namely: (a) call switching-recording and (b) machine billing. The first of these, telephone call switching-recording, falls within the scope of the traffic and equipment departments; machine billing falls exclusively within the accounting department. While coordination of the switching-recording and machine billing functions is essential, the

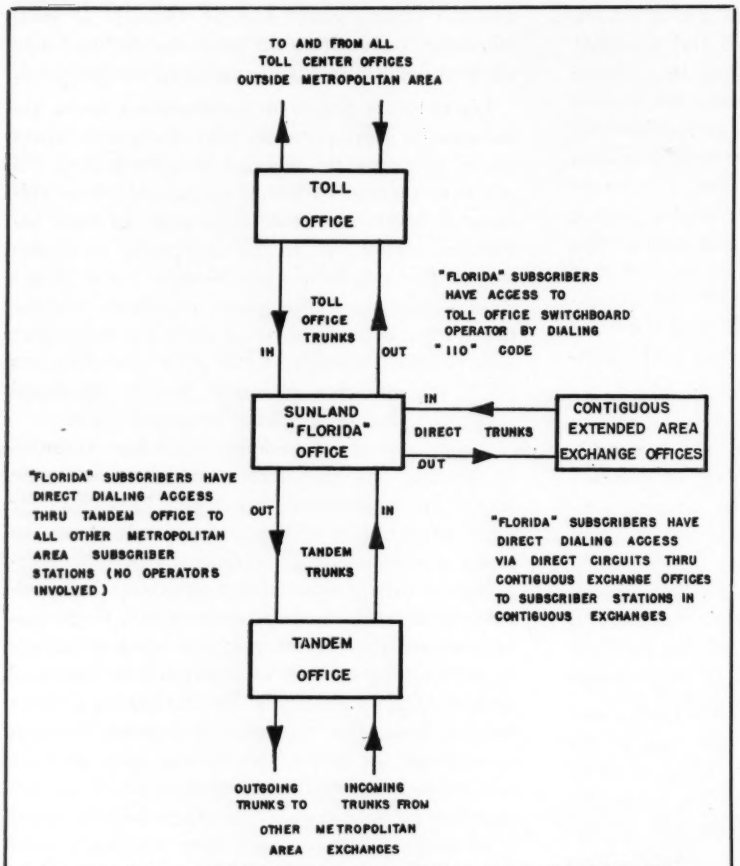

Figure 3. Schematic of Toll Trunking. Sunland (Los Angeles "Florida") Office.

two lend themselves to separate analysis with a wide selection of machine billing alternatives available to interpret the records produced by the telephone switching mechanism, thus leaving to economics and operating preference the selection of apparatus and services for the accounting department.

This section of the discussion will be confined to consideration of the procedural elements involved in the telephone switching-recording operation, reserving for a subsequent section the analysis of accounting alternatives.

Basically automatic toll ticketing accomplishes the transference of record making on toll traffic from the traffic or switchboard operating department of the telephone company to the equipment department. Circuit design and switch maintenance displace the problems of switchboard design, force adjustment and personnel as the predominant ingredients of providing and protecting the service. The attendant economic and procedural results of this transfer of responsibility will be analyzed in succeeding sections with emphasis in the following paragraphs upon the mechanical and circuit features of the equipment performance.

The central office equipment features of automatic toll ticketing operation were the subject of two recent technical papers. Since both of these papers were specifically applicable to the installation now in operation in the "FLorida" Exchange of Los Angeles located in the Sunland community, the following paragraphs constitute excerpts describing the performance of this apparatus. In these papers and hereinafter in this article the central office toll recording equipment is referred to as the "SATT System", abbreviation for "Strowger Automatic Toll Ticketing" system. The first reference paper was entitled "Automatic Call Ticketing in Metropolitan Telephone Areas" written by Mr. John E. Ostline, Systems Development Engineer, Automatic Electric Company, Chicago, Illinois, who, as has previously been stated, was one of the principals in the invention and development of the equipment; this paper was presented before the Western Society of Engineers on December 9, 1946 and was printed in volume 52, March 1947 of the Journal of the Western Society of Engineers. Referring to the diversity of needs to be met by the toll ticketing apparatus, Mr. Ostline in

his paper is quoted as follows:

"In arranging an automatic toll ticketing system for any metropolitan area AB toll network, study of various types of operating practices discloses the fact that operation administrations (telephone company management) in every network considered for automatic toll ticketing require different features, facilities and operating methods. For instance, in some networks a special "toll prefix" numbering plan for AB toll calls is satisfactory, while in others it may be desired to use only the regular directory listings of subscriber call numbers without special toll prefixes. Similarly, in some cases automatic computation of the charge for each message, and sometimes added to this, complete automatic or mechanical billing facilities may be desired, while in other cases only a record of the calling party, date and conversation time for each toll call is satisfactory.

"From the foregoing general considerations it will be noted that in its application to any given network, an automatic toll ticketing system should have considerable inherent flexibility. This problem of a flexible toll ticketing system has therefore been met in the same way as in step-by-step automatic switching; i.e., by designing a number of basic SATT system components which can be interconnected in several combinations to produce whatever features and facilities may be desired by the operating administration in any particular network or area for which automatic toll ticketing operation may be considered."

Mr. Ostline's paper should be read in its entirety by engineers interested in ascertaining the full capacity and flexibility of the apparatus referred to.

In a more recent paper presented before the Annual Convention of the California Independent Telephone Association in Los Angeles, California on June 23, 1949, Mr. L. L. Ruggles, Chief Sales Engineer of Automatic Electric Sales Corporation analyzed the specific application of SATT equipment to the circumstances of service and traffic prevailing in the "FLorida" (Sunland) office. Mr. Ruggles' discussion of these operations is quoted in part below:

"The tandem office (indicated in Figure 3) is operated by The Pacific Telephone and Telegraph Company. For tandem operation the Sunland equipment is capable of completing calls through tandem exchanges of either the step-by-step or cross-bar type although initially the tandem office involved will employ step-by-step operation.

"Figure 4 shows in schematic form the classes of calls to be made by local subscribers and the method of handling each type of call. Three classes of subscribers are shown: (A) Local Rate, (B) Extended Rate, and (C) Paystations. Five general classifications of calls are illustrated:

1. Local calls which are dialed by local subscribers through the central office equipment directly to other local subscribers.

2. Long distance calls (beyond the Metropolitan network) which must be routed to an operator at the long distance toll office.

3. AB or short-haul station-to-station toll calls which must be routed through Automatic Toll Ticketing equipment and thence to any one of the exchanges in the metropolitan area to be served on the AB (subscriber dialing) toll plan. These exchanges are located in six different AB toll zones (marking the extent of the subscriber dialing range). The Local Rate subscriber is charged a standard toll rate for such AB (subscriber dialed) calls, while the Extended Rate subscriber is charged at unit rates.

4. Extended (free) calls, which can be made only by Extended Rate subscribers to specified exchanges in adjacent exchange areas.

5. Paystation calls which require the assistance of an operator for all toll, AB or Long Distance.

"To accomplish this sorting and routing of calls requires equipment which will recognize the destination of the call from the code dialed by the originating subscriber. It is further necessary that the equipment recognize instantly the class within which the calling subscriber falls, that is, Local Rate, Extended Rate, or Paystation. The equipment which is now operating in Sunland to accomplish this purpose is known as the Director. This Director is capable of: (a) recognizing the rate class in which the subscriber falls; (b) determining the route which the call should take to its destination as shown on the diagram; and (c) completing the connection by controlling the switching equipment. It will not be necessary to describe the process by which the local calls or long distance calls are completed since we are confining

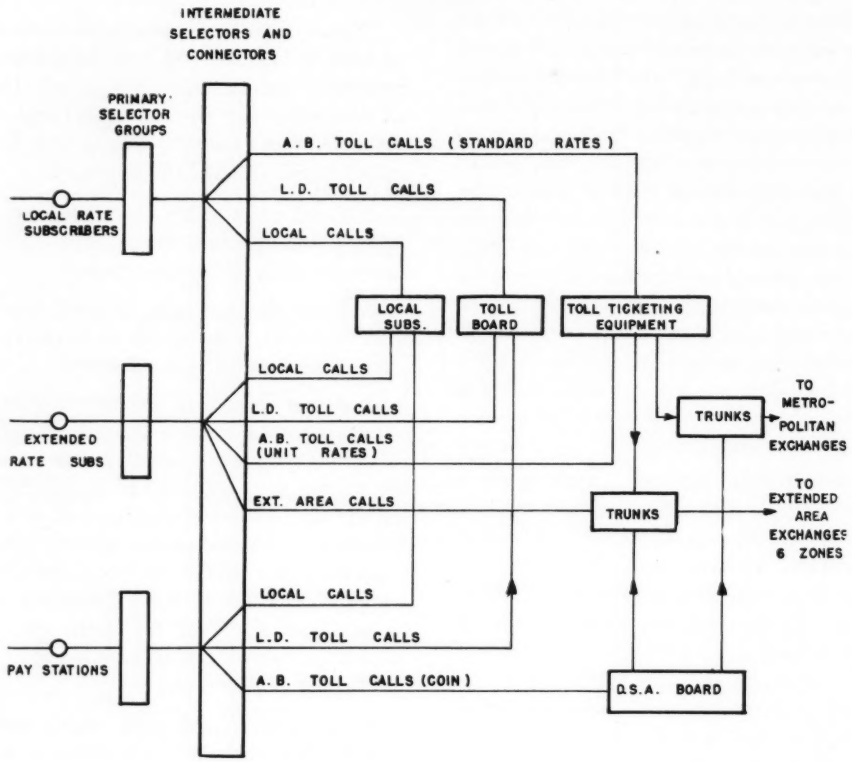

Figure 4. Schematic Showing Call Classification and Distribution.

this discussion to Automatic Toll Ticketing as it applies to the AB (subscriber dialed) toll calls in the area.

"Figure 5 indicates schematically the process by which AB toll calls are completed. No attempt has been made to show all of the local switching equipment; however, a primary selector is shown, equivalent to a first selector, to which the subscriber's line is connected when a call is initiated. Associated with the primary selector is a device known as a Director Hunter which immediately searches over a common group of Directors for one which is not occupied. Upon seizure, the Director will return dial tone to the line. On the average, the subscriber will receive dial tone within one second. The subscriber proceeds to dial the desired number which is registered in the Director.

"From the first three digits dialed by the subscriber the Director determines the proper routing of the call. For this purpose, the Director closes a circuit path to a Translator, which interprets the code dialed by the subscriber. The Translator instantly registers in the Director the translated code, known as a "directive". This operation requires 200 milliseconds or less.

"The routing of the call and other important control and record functions depend upon this directive. The Director uses the directive to complete the call, and to transmit essential data to the ticketing equipment.

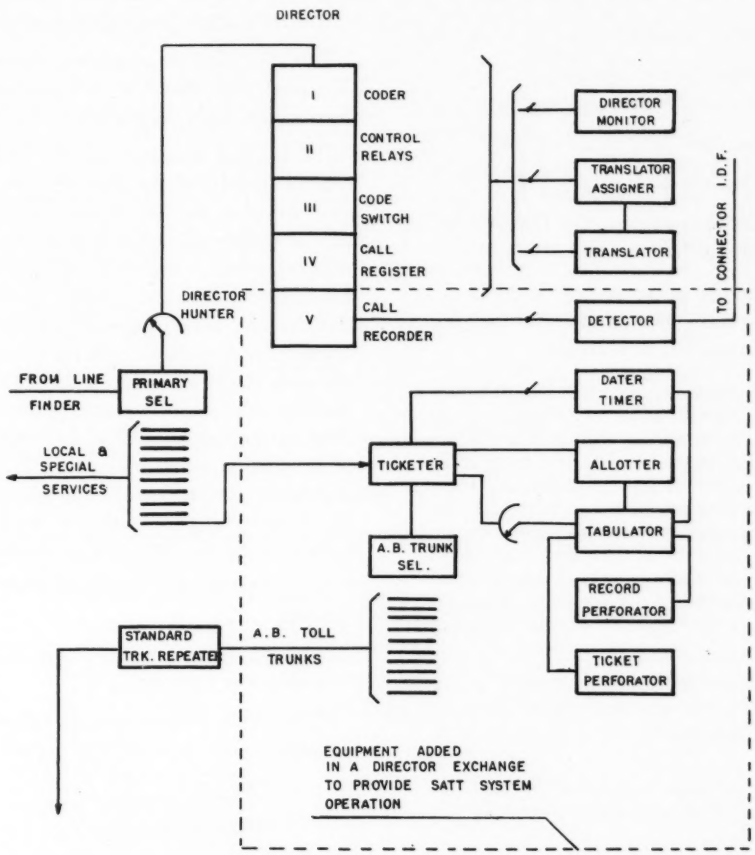

Figure 5. Switching Schematic for Director and Toll Ticketing Equipment.

"A call to a central office in Los Angeles reached through a step-by-step tandem office will be routed by the Director in the following manner:

The first digit of the translated office code (or Directive) will cause the primary selector to occupy a circuit to a Ticketer with which is associated an AB trunk selector. The next digit transmitted by the Director will operate the AB trunk selector to a level corresponding to a trunk group to the tandem office, and seize an idle trunk to a selector in that office. The Director will then control the sending of sufficient digits to select a path to the terminating office and finally will repeat the last four digits as dialed by the caller to select the called station.

"If and when the Sunland equipment shall be required to route calls through a crossbar tandem office, the Sunland Director will route the call to the tandem and then transmit the complete seven-digit directory number into the crossbar registers which will then take over to complete the routing of the call. The Director function in this case may be contrasted with the requirement for routing calls direct to step-by-step offices. In the latter case the Director routes the call by sending only two office-selector digits and then the four digits representing the subscriber's number.

"Simultaneously with the transmission of the switching control impulses, the Director also trans-

mits to the Ticketer the following coded information regarding the call which is in progress.

1. Calling station number.
2. Calling station class of service (i.e. local rate or extended rate)
3. Called station number.
4. Called station zone.
5. Identification number of the Director involved in the call.

"While the call is being routed to its destination the Director has collected and recorded all of this essential information as follows:

1. The calling subscriber's number is obtained by the Director from two sources: from the subscriber's identifier dial which identifies any of four parties on a line, and from the Detector which it momentarily calls into action. The Detector searches over all the connector terminals in the exchange within a period of two seconds or less and records, in the Director, a code number representing the calling subscriber's connector terminal number, which corresponds to his directory number.
2. The class of service information is obtained from the segregated group of primary selectors through which the call was originated.
3. The called station number was registered in the Director from the digits dialed by the calling subscriber.
4. The called station zone was also indicated by the exchange name or code dialed by the calling subscriber.
5. The Director identity number is a circuit function of each Director in which individual jumpering controls the identification code transmitted to the ticketer.

"These five items remain stored in the Ticketer until the call is completed.

"The call by the time the foregoing operations are complete has reached its destination and the Director has detached itself from this series of operations. The average time of occupancy of the Director on ticketed calls is 17 seconds. Local calls occupy the Director for about 6 to 7 seconds. If the called station is busy, the proper signal is returned to the calling subscriber who upon restoring the handset to its cradle will release the complete train of switches including the Ticketer with all its stored information. Likewise, an unanswered call will result in the same restoration of equipment when the calling party abandons the call.

"At this point no recording equipment has been occupied and therefore no partial records have been made. Only completed calls are recorded.

"If the call is answered, the Ticketer will close control circuits to the Dater-Timer unit and start the timing of the call. Conversation time in minutes is registered and stored in the Ticketer. The release of the connection at termination of the conversation is under control of the calling subscriber. This action stops the timing and causes the Ticketer to lock itself in its operated position while allowing the balance of the switch train to release, thereby releasing all trunk paths for other calls. This self locking operation also starts the recording of the call on a perforated tape under control of a Tabulator which is automatically associated with the Ticketer at termination of the call. The Tabulator controls two separate perforators.

1. The Ticket Perforator, for billing purposes.
2. The Record Perforator, for traffic and maintenance purposes.

"The Ticket Perforator punches a tape which records in code the following information:

1. Date.
2. Clock time.
3. Calling station number.
4. Calling station class of service.
5. Called station number.
6. Distance by zone called.
7. Conversation time in minutes.

"The Record Perforator records all of the above information and in addition the identity number of the Director used to set up the call and the identity numbers of the Ticketer and Tabulator. Figure 6 shows a typical record tape.

"The ticket tape may be used to control a printer which will print a ticket containing all of the essential information. Alternatively, the tape may be fed through a machine which will punch a tabulating card for each call. The cards may then be sorted by machine and used to print the subscribers' bills automatically.

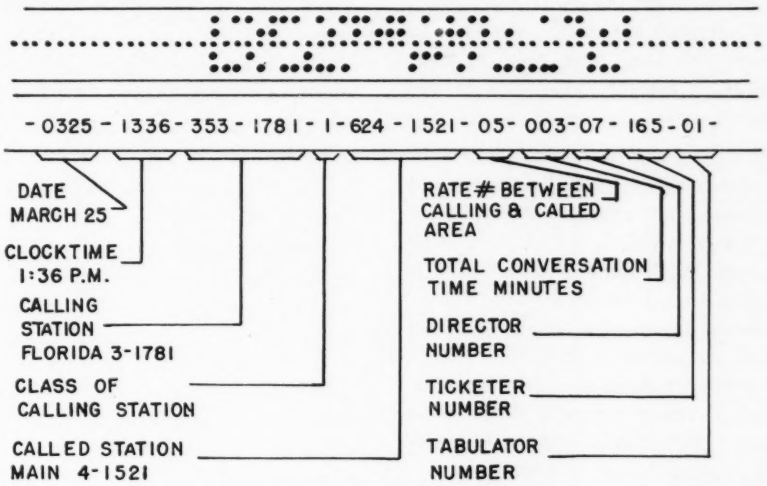
- 0325 - 1336 - 353 - 1781 - 1 - 624 - 1521 - 05 - 003 - 07 - 165 - 01 -
DATE MARCH 25
CLOCKTIME 1:36 P.M.
CALLING STATION FLORIDA 3-1781
CLASS OF CALLING STATION
CALLED STATION MAIN 4-1521
RATE # BETWEEN CALLING & CALLED AREA
TOTAL CONVERSATION TIME MINUTES
DIRECTOR NUMBER
TICKETER NUMBER
TABULATOR NUMBER

Figure 6. Typical Record Tape.

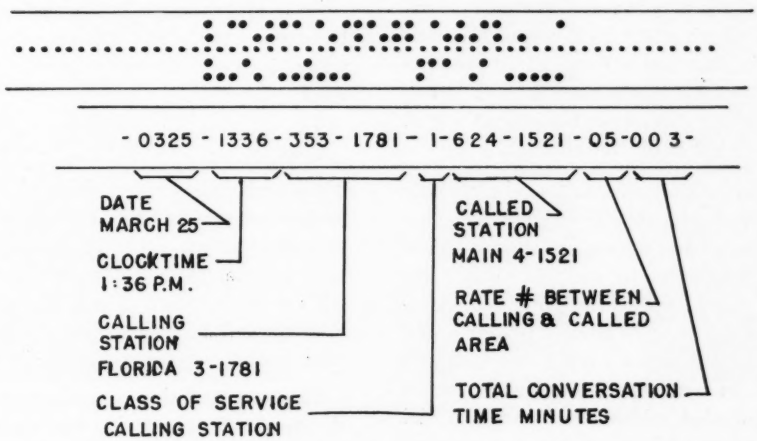
- 0325 - 1336 - 353 - 1781 - 1 - 624 - 1521 - 05 - 003 -
DATE MARCH 25
CLOCKTIME 1:36 P.M.
CALLING STATION FLORIDA 3-1781
CLASS OF SERVICE CALLING STATION
CALLED STATION MAIN 4-1521
RATE # BETWEEN CALLING & CALLED AREA
TOTAL CONVERSATION TIME MINUTES

Figure 7. Typical Ticket Tape Without Total Computed Charges.

"The Strowger Automatic Toll Ticketing System (SATT System) has the inherent flexibility which permits the operating telephone company to choose the system of billing which it considers best suited for its own particular needs. Preceding paragraphs have touched upon these variations but it may be interesting to examine them in more detail.

"Company 'A' prefers to use printed toll tickets containing only the information which an operator would normally write on the ticket. These tickets will be sorted manually and the total charge will be calculated from the information printed on the ticket. The total charge will be entered on the ticket and billing will be done in the usual manner, the essential information being copied on the subscriber's bill. To meet this condition, the Tabulator which controls the Ticket Perforator, would con-

tain only the essential apparatus for producing a tape recording of the basic information required, exclusive of the computation of the toll charge. Figure 7 illustrates this tape. The punched tape, when run through a printer, will produce the printed information shown.

"Company 'B' desires a little further refinement by having a complete ticket printed which would include the computed toll charge. This plan requires a Tabulator to which is added computing equipment to enable the Tabulator to control the Ticket Perforator so that the resulting tape will record the total computed charges. The tape, when processed through the printer, will produce a complete toll ticket similar to those already shown, but with the addition of figures representing the total computed charges. This eliminates the necessity for manually calculating the toll charge.

"Company 'C' (as in the case of the Sunland installation) finds it economical and desirable to carry the process of mechanical billing to its ultimate. Here the ticket tape is passed through a card punch machine which will punch a card for each call. The card in this case will record all the necessary information for processing through automatic tabulating and computing equipment which prints a complete bill ready for mailing."

To provide all of the advantages of automatic toll accounting to four-party line subscribers a specially designed subscriber station dial is used on the calling party's telephone in the "FLorida" Exchange. These dials do not differ from the standard dial in size or in any outward features, the identifying mechanism being a small cam mounted on the rotor shaft with associated spring contact features, all included within the standard dial housing. Quoting Mr. John E. Ostline:

"When one of these dials is operated, it also delivers station identification pulses during the sending of the regular switch positioning pulses. During the second prefix digit these pulses are recorded in the translator and from there the indication is transferred to the Director. When the Director calls in the Detector, this station indication is passed to it. The Detector will then search for the calling station in only those groups of terminals which serve stations of the particular class indicated. First party stations are handled the same as individual stations. No special line or terminal equipment of any kind is required in the exchange for identification of either individual or two-party stations."

Mr. Ostline in his paper has also stated in connection with the toll ticketing Director as follows:

"The Director in the SATT system is not a new unit especially designed for it, but a regular type Director arranged to provide the required facilities for toll ticketing.

"The Automatic Electric Director was designed 25 years ago to provide registration, translation and sending control for any type or class of step-by-step automatic switching system where completion of a desired connection requires switch positioning pulses or controls entirely different in numerical value and amount from the pulses provided by the digits of a dialed directory number. The Director can also send pulses and provide controls to operate switching equipment and apparatus arrangements different in operating characteristics from those of step-by-step switching equipment.

"In addition to the foregoing basic functions the Director also provides a number of other facilities which include 'alternative routing', and 'class of service' controls."

The SATT equipment is so designed as to prevent the passing of free or unidentified subscriber dialing toll calls. Failure of identification apparatus because of subscriber dial faults or faulty grounds at subscriber stations automatically refers the call to a manual DS"A" position for call completion with manual ticketing and for trouble reporting. The apparatus also possesses self-contained testing devices and trouble routining circuits.

Equipment design and costs required to serve the needs of any specific exchange are, as in the case of local dial equipment, the function of peak traffic loads and number of subscriber terminals served. Significant data for the "FLorida" office in designing the equipment layout as well as in trunking and quantity calculations were as follows:

1. Subscriber-dialed toll calling attempts at busy hour peak — 1,000 per hr.

2. Total outward dialing attempts, subscriber dialing, 24 hour basis (including incompleted calls) — 10,000 per day

3. Monthly call completions subscriber-dialed calls — 100,000 per mo.

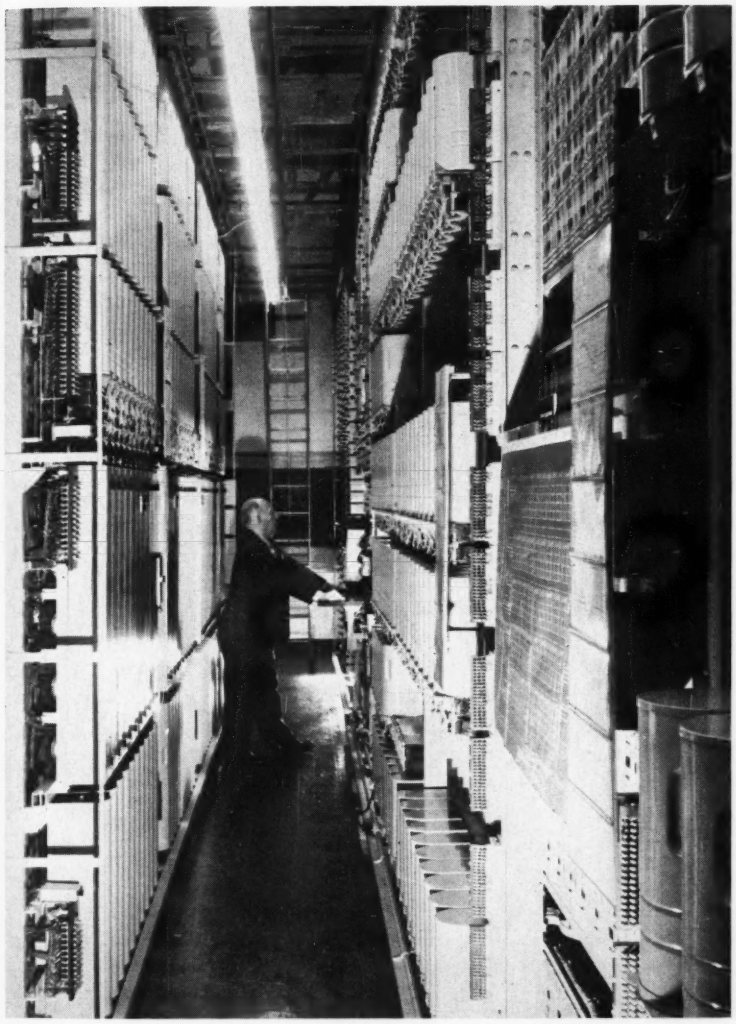

Figure 8. View in Sunland Switchroom. J. E. Ostline Is Shown at Monitor Panel with back to Director Frames.

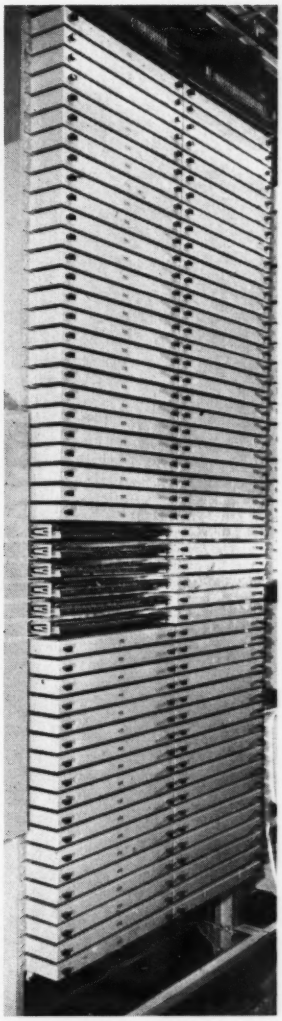

Figure 9. Five-thousand Terminal Detector Frame Fully Equipped.

4. Monthly call completions operator-dialed calls 6,000 per mo.

5. Subscriber lines served 2,940 lines

6. Subscriber terminals served 6,000 terminals

Subscriber access by direct dialing is increased under automatic toll switching operation to 1,250,000 telephones from 6,000 for local service subscribers and from 96,000 for extended service subscribers.

To achieve the required service capacity indicated above the Sunland installation includes 34 Directors, 60 Ticketers, 6 Ticket Perforators and 6 Record Perforators. Figures 8 to 12 inclusive, made from photographs taken in the Sunland central office, show some of the units of apparatus described in this section.

The following section of this paper will analyze the cost considerations applicable to the selection of automatic toll ticketing methods in the light of the requirements of traffic quantities and station development tabulated above.

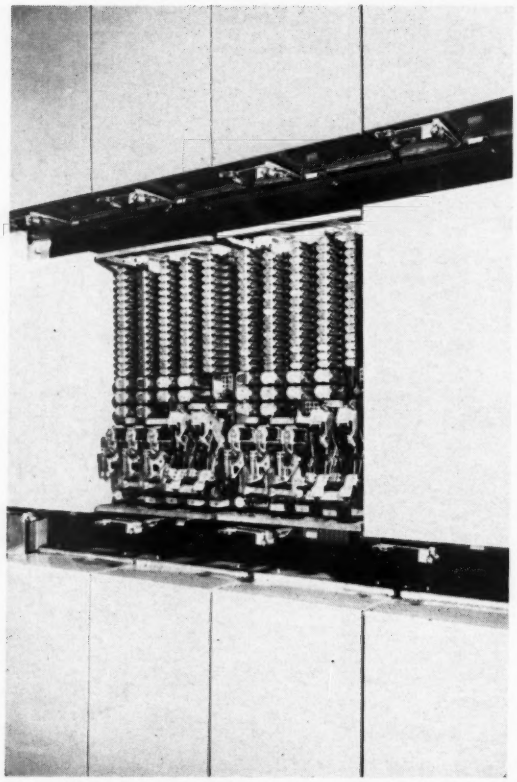

Figure 10. Ticketer Frame Showing Two Ticketer Details.

Economics of Central Office Equipment Selection

While subscriber preference for direct dialing service and for the elimination of switchboard operators in the completion of calls may be taken for granted, the economic advisability of offering this type of operation is controlled by the traffic and operating characteristics of any given exchange and arbitrary adoption of automatic call accounting procedures without first investigating the economic results is to be avoided. The design of modern switchboard equipment, including key-sending equipment and circuit arrangements taking maximum advantage of tandem and direct routing to toll dialing area and metropolitan area exchanges, render *operator* dialing and recording procedures highly satisfactory and efficient as well as acceptable from a commercial standpoint; wherever economic advantage rests with this type of operation it may be desirable to continue to expand on this basis. On the other hand, as in the case of the Sunland office, the transferring of dialing and recording operations from a switchboard operator to the subscriber wherever feasible may show economic justification as well as exploit the subscriber's commercial preference. Referring to Table I herein it will be noted that total annual charges for continuing on an operator dialing and recording basis

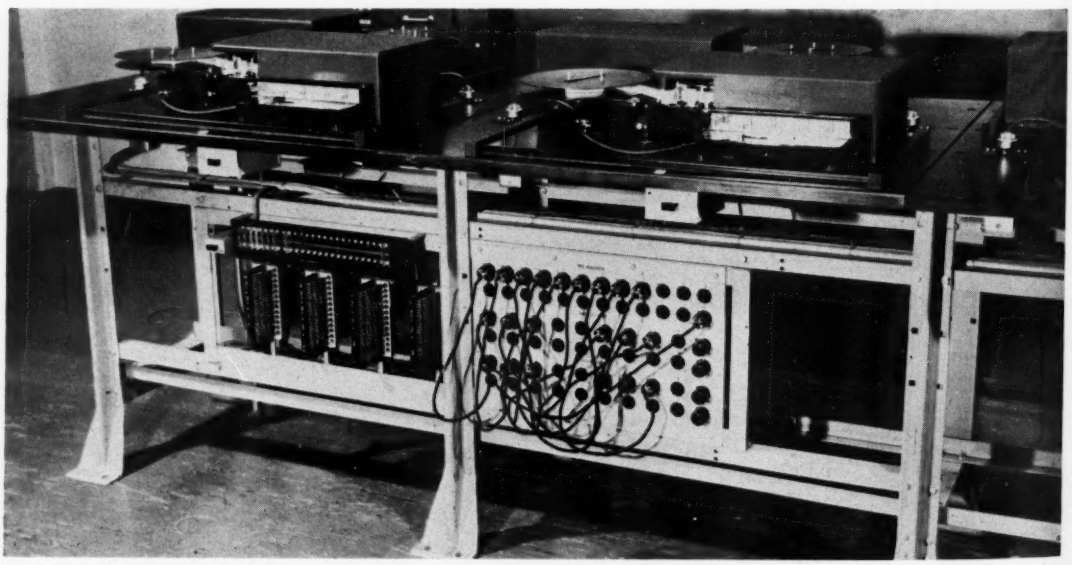

Figure 11. Tape Perforators Showing Table Mountings and Perforator Patch Panel.

at Sunland compute to $99,500 per year and equate to an allowable added investment of $326,600 to install SATT operating features before exceeding the annual costs of operator dialing.

It was possible in Sunland to add the automatic toll ticketing operation to a local dial operation previously designed for the purpose, having Director equipment, terminal-per-station features and initial identifier dial equipment installed on subscriber stations. These circumstances might result in contrast to the economic calculations for a situation wherein the addition of automatic toll ticketing operation would require major basic changes in the local automatic equipment as, for example, (1) increasing or modifying telephone number digit prefixes to come within a coordinated numbering plan, (2) conversion from terminal-per-line to terminal-per-station operation, (3) the addition of "Director" operation to a standard terminal-per-station installation, or (4) the complete change out of local subscriber dial equipment for identifier dials and the addition of station grounding circuits to acquire four-party identification features. In many instances throughout the country all of this list of changes and possibly others would be required to give effect to automatic toll ticketing operation and in all cases except where, as in Sunland, the initial local automatic office is "Director" equipped at least the last two of these modifications would be required. When the cost of such changes is to be added to the calculation of annual charges it is possible that these factors in themselves or in combination with less appealing traffic characteristics would defeat the economic argument for subscriber dialing. It is true, however, that the pressure of commercial demand for greater subscriber dialing access and the possibilities for attaining the economic advantages exemplified in the Sunland installation should be regarded as important factors in the design of additions and changes for any metropolitan area dial office with the thought in mind that sooner or later the proper economic environment may appear for the offering of the automatic toll service.

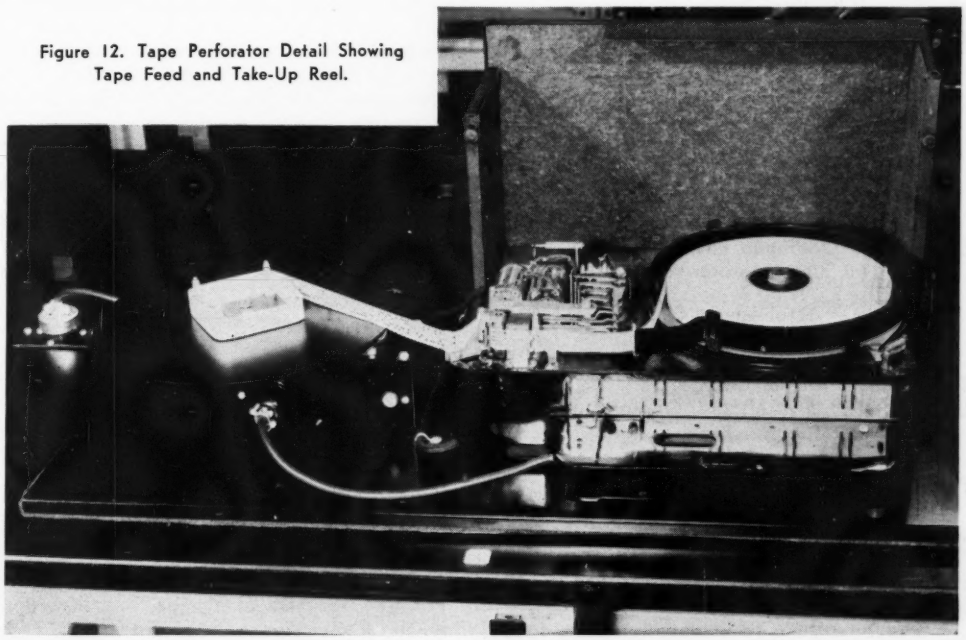

Figure 12. Tape Perforator Detail Showing Tape Feed and Take-Up Reel.

It was true in the Sunland installation and will probably hold for most cost comparisons in similar localities that the cost of floor space occupancy and the usage of incidental materials such as stationery items will not vary consistently or to any significant degree for the purpose of contrasting operator dialing costs with subscriber dialing costs; these factors have therefore been considered com-

Table I

ANNUAL COSTS

Manual Toll Office vs. Automatic Toll Office
(Service to 2,940 Subscriber Lines and 6,000 Subscriber Terminals)

Manual

Required Manual Toll Investment		
8-position Toll Switchboard (installed)		$ 51,400.00
Toll circuit equipment in dial office including fourth selectors, toll repeaters and associated mounting and other toll apparatus (installed)		64,400.00
Total Investment		$115,800.00
Annual Charges		
Fixed Charges		
Depreciation @	3.0%	
Property Taxes @	2.4	
Insurance and Protection @	1.0	
Interest and Earnings @	7.0	
	13.4%	$ 15,500.00
Maintenance @ 2 man-years		7,200.00
Switchboard Operating Payroll @ 32.0 operator-years		76,800.00
Total Annual Charges		$ 99,500.00

Automatic

Total Manual Annual Charges		$ 99,500.00
Less: D.S."A" Switchboard Operator Payroll required with Automatic Toll Ticketing @ 10.0 operator-years		24,000.00
		$ 75,500.00
Fixed Charges on Automatic Equipment		
Depreciation @	3.0%	
Property Taxes @	2.4	
Insurance and Protection @	1.0	
Interest @	7.0	
Maintenance @	5.0	
	18.4%	
Capitalizing $75,500 per year @ 18.4% to determine total allowable "break even" central office toll investment		$410,000.00
Less:		
4-position D.S."A" switchboard	$19,000	
Toll circuit equipment	64,400	83,400.00
Allowable increment of investment to mechanize toll switching		$326,600.00

mon to both plans and were eliminated from the study on both the manual and automatic sides.

An analysis of costs is essential also to the determination of commercial and equipment planning in respect to the choice between (a) offering subscriber dialing and "SATT" operation to one-party and two-party extended subscribers only, or (b) offering the service to local and four-party subscribers as well.

Geographical location of a given exchange with

Table II

TOLL TRAFFIC DISTRIBUTION

August, 1949

	Class of Traffic	No. of Messages	% to Met. Area Toll	Total Billed Revenue	Avg. Rev. per Message
1.	Completed, Ticketed "message unit" calls (originated by ext'd. service subscribers)	27,896(a)	37.1	$ 4,070.00	0.146
2.	Completed AB full rate "station" calls (originated by local service subscribers)	36,019	47.9	6,823.20	0.189
3.	Completed AB full rate "station" coin box calls	10,528(b)	14.0	1,610.35	0.153
4.	Sub-total Metropolitan Area "Station to Station" traffic	74,443(c)	99.0	12,503.55	0.168
5.	Incoming "Collect" calls from Metropolitan Area	547	0.7	264.00	0.483
6.	Out "person" calls to Metropolitan Area	249	0.3	151.70	0.609
7.	Sub-total all Metropolitan Area Traffic billed to Sunland subscribers	75,239	100.0	12,919.25	0.172
8.	Long Distance beyond Metropolitan Area	1,903		3,169.40	1.663
9.	Total outward completed toll traffic billed to Sunland subscribers	77,142		$16,088.65	0.208

(a) Message unit revenues charged at full rate discounted 30%; free calling access including 6 adjacent office areas 95,978 stations.
(b) Coin box traffic (10,528 calls) not subject to automatic ticketing or to billing procedures.
(c) Corresponds to subscriber dialing range.

respect to other exchanges in a metropolitan area has a major influence upon demand for extended service and upon calling characteristics. An exchange entirely surrounded by other exchanges all containing uniform, dense development is apt to offer more universal appeal for extended free calling usage than a "fringe" or perimeter exchange usually having a greater local suburban community life and a lesser degree of need for the "free" access to adjacent areas. Thus an extended service one-party and two-party development of eighty percent or better might be normal for a centrally situated exchange while twenty-five percent to fifty percent would be equally typical for a "fringe" area; it is impractical to generalize for all exchanges on the desirable choice of subscriber dialing access as between offering this service to *all* subscribers or offering it only to single and two-party subscribers. Granted that commercial demand establishes a prejudice favoring *complete* subscriber access, the problem is fundamentally a question of economics. If the extended service rate structure has reached a level of discrimination against low volume users and prohibits the elimination of the optional subscriber choice between four-party and higher grades of service the question poised is "Will the additional investment and carrying charges to offer subscriber toll dialing to local service and party-line subscribers be justified by the attendant savings in manual payroll and manual switchboard costs?"

The Sunland installation produced an affirmative answer to this question even to the extent of proving that the entire automatic ticketing conversion would show little or no savings unless the service were offered to all subscribers.

As evident from Figure 2, Sunland is a "fringe" exchange lying at the northern extremity of the Los Angeles Metropolitan Area. It is also a toll operating company owning its own toll lines and over the years has operated its own toll switchboard to handle all Metropolitan area calls and some long distance calls. Out of a total investment in 1950 of $1,878,000 twenty-five percent or $467,-

Table III

SUBSCRIBER DISTRIBUTION

August, 1949

Type of Service	No. of Telephones	% of Total
1. Extended Service (1-party & 2-party)	1590	34.4
2. Local Service (1, 2 and 4-party)	3039	65.6
Total	4629	100.0

000 was exclusive toll investment, including automatic toll ticketing. The company's toll traffic distribution in August 1949 is tabulated in Table II herein. The corresponding subscriber distribution between extended service and local service is shown in Table III.

The 34.4% extended development in August (Table III) originated only 37.1% of the tolls in the subscriber dialing range (Table II) thus ostensibly leaving the choice in offering automatic ticketing lying between 37.1% elimination of manual toll operating margin if only extended subscribers were offered access to automatic ticketing as compared to an additional 47.9% of traffic economy if the entire exchange were to be converted.

The contrast between the alternatives is further accentuated by the traffic "peaking" characteristics. Equipment quantities and corresponding costs being a function of peak loads, the impact of these peaks at Sunland was analyzed. Usage in the exchange develops two daily peaks of almost equal magnitude, one occurring 10:00 A.M. to 12:00 Noon on week days (a business calling peak) and the other occurring 6:30 P.M. to 8:30 P.M. (a social calling peak). Popularity and distribution of extended service and local service respectively have created the condition of the morning "business" peak being dominated by the *extended* service group; whereas the evening "social" peak is dominated by the party-line residences or *local* service group. Since the Director system and ticketing equipment are common to both groups it is obvious, therefore, that practically as much such equipment would be required to serve the extended service group alone as for serving both groups. By making the facility available to *all* subscribers the result is to smooth out the overall equipment economy to cover both peaks with the same apparatus. Taking the other view of the same circumstances, if the SATT equipment *could not* handle the evening local, party-line subscriber peaks sufficient manual switchboard and operating personnel to do so would have to be provided, thereby to a large extent upsetting the entire economic argument for SATT performance and introducing the extravagance of duplication.

Interpreting and Billing Toll Tickets

Significant factors influencing the selection of methods for the interpretation and the ultimate billing of toll charges are (1) previously established methods of billing for a given company, (2) the degree to which uniformity of billing methods is to be sought, (3) relative quantity of toll tickets produced in the *subscriber* dialing range as against toll tickets produced in the *operator* dialing range, (4) the availability and arrangement of floor space for revenue accounting and for filing and (5) the proximity and efficiency of service of available accounting methods firms capable of supplying and servicing billing machines. The final determination of the appropriate choice in the light of all of the foregoing factors is necessarily established by the economics of available alternatives; these economics will be the subject of a subsequent section of this paper, this section confining itself to a general review of the respective operating features.

The automatic toll ticketing central office equipment installed in the Sunland office does not compute the total charges applicable to each toll ticket,

but if practical and economical such a computing feature might have been included at an additional cost of approximately $30,000. All economic and operating advantages rested with the elimination of the computing feature and with confining the tape record to the ingredients of the rating calculation (conversation time and distance or zone data). The calculation of total charges by machine methods is conducted *after* the ticket tape has been removed from the perforators for interpretation. The manual rating of tickets by eye examination of time and distance data and comparisons with printed rate charts and tax charts would necessitate, as some intermediate step before the preparation of customer toll statements, the listing of all data in printed or otherwise legible form. On the other hand, mechanical interpretation of key punched data appearing on such a record as is illustrated in the tape perforations of Figure 7 eliminates any need for a printed record. The calculation of excise taxes and total charges for any given call is accomplished by a matching process wherein a master deck of tabulating cards is brought into appropriate arrangement with tickets requiring rating and the charges are machine punched in the appropriate columns of the tabulating card at a savings in time as compared with the requirement of a printed ticket and manual interpretation.

As a matter of commercial policy and to establish legal identity of the original toll record produced by automatic toll ticketing equipment for use in customer contacts and to comply with legal filing periods it is necessary to distinguish a specific record in the billing process to be formally designated as the "toll ticket". The concept adopted in the Sunland-Tujunga Telephone Company for these purposes contemplates that the tabulating card illustrated in Figure 13 is to be regarded as the toll ticket and that the coded record appearing in perforated symbols on the tape (a standard teletype tape) is nothing more than an instrumentality in the mechanical process of producing the tabulating card, corresponding with the switchboard operators' pencils or calculagraphs in a manual system in its relationship to the ultimate toll ticket. The tabulating card lends itself to sight reading and convenient permanent filing, both essential to an original toll ticket record. For the same reasons a company not electing to use tabulating card billing methods would probably select the printed ticket form as the original toll ticket record rather than the continuous perforated tape which would require complicated decoding interpretation.

Machines capable of automatically producing tabulating cards from continuous tape records on an unattended basis are produced by at least two business machine firms. International Business Machines equipment is employed in the Sunland system and a four-hole code is used on the tape. The column headings appearing on the tabulating card illustrated in Figure 13 denote the class of information falling in the respective columns and the order in which the data are decoded from the tape. Since only 40 vertical rows of figures are required to show all essential data on the tabulating card toll ticket and the capacity of the card is 80 rows, each card may be used twice, giving a complete toll ticket record in two separate billing periods and reducing the cost of tabulating card stationery to one-half of the cost for single usage.

The four-hole code and tape position assignments used on the Sunland tapes to actuate a Type 042 Automatic IBM Key Punch and produce the tabulating card toll ticket are as follows:

DIGIT CODE

Digit	*Punch Positions (Top to Bottom Fig. 7)*
1	1, 2
2	1, 3
3	1, 4
4	2, 3
5	2, 4
6	3, 4
7	1
8	2
9	3
0	4
Symbols	
Record start	1, 2, 3, 4
No third called code digit (used to adapt code to 6-digit as well as 7-digit directory numbers)	1, 2, 3

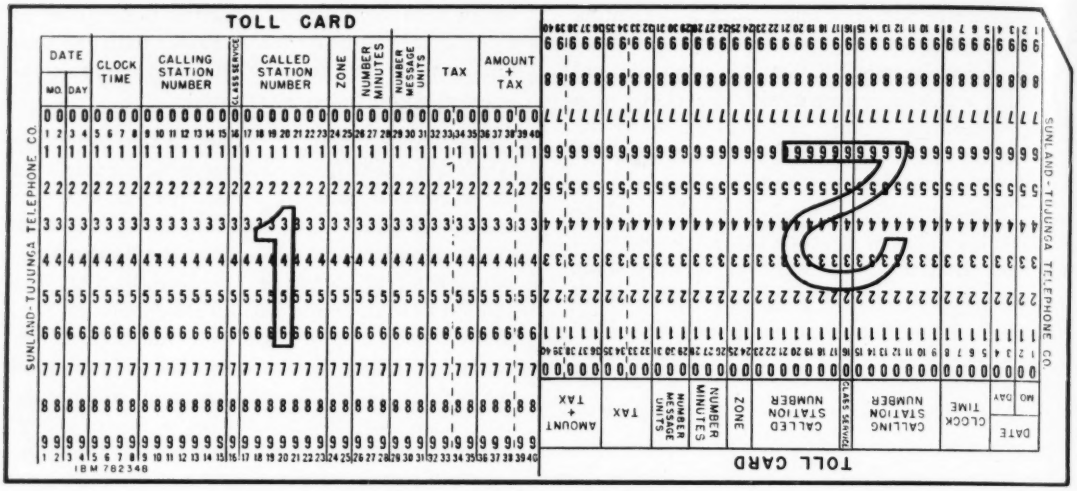

Figure 13. Tabulating Card Toll Ticket.

TAPE POSITION ASSIGNMENTS

Item	*Spaces*	*Tape Position*
Start	1	1
Date	4	2-5
Clock time	4	6-9
Calling station number	7	10-16
Calling station class of service	1	17
Called station number	7	18-24
Called station rate	2	25-26
Conversation time	3	27-29

To facilitate an outside tape feed on the ticket printer or automatic key punch the SATT perforator places the above data on the ticket tape in reverse sequence (last item first). Spaces 29 thru 40 on the toll ticket, Figure 13 (number of message units, tax and total amount) are computed by IBM processes and do not appear on the tape for decoding.

As in *rating* toll tickets a contrast between mechanical vs. manual methods of *sorting* is created by the difference between automatic electric sensing of key punch perforations as against the manual scanning of telephone numbers by eye and the use of human hands in segregating the tickets by calling telephone number. Likewise *listing* and *summation* by manual methods to obtain the total toll charges for each telephone number in an exchange requires eye scanning and the depression of a typewriter, billing machine and/or adding machine key for every digit in each figure representing the month, day, called party's number, tax and total charges.

The resulting toll statement produced by the overall mechanical process of rating, sorting, listing and summation is illustrated in Figure 14. The listing and summation operations are combined in one tabulator machine performance without the necessity for typewriter or adding machine operation, thus achieving a savings in time and personnel.

The "register sheet" or accounting control summary constituting the company's records to be retained for general accounting purposes and for balancing is illustrated in Figure 15 and is also produced automatically by the tabulator from the monthly file of tabulating card toll tickets without the necessity for manual printing or calculation. This control register balances each billing period against the accumulation of toll statements produced by the same file of tabulating cards. Here again typewriting, writing and adding machine operation under manual attendance and subject to the inevitable delays imposed by human error and balancing are eliminated in favor of mechanical speed and precision.

After preparing the toll statement illustrated in Figure 14 it is necessary to combine the total charges summarized on each statement with ex-

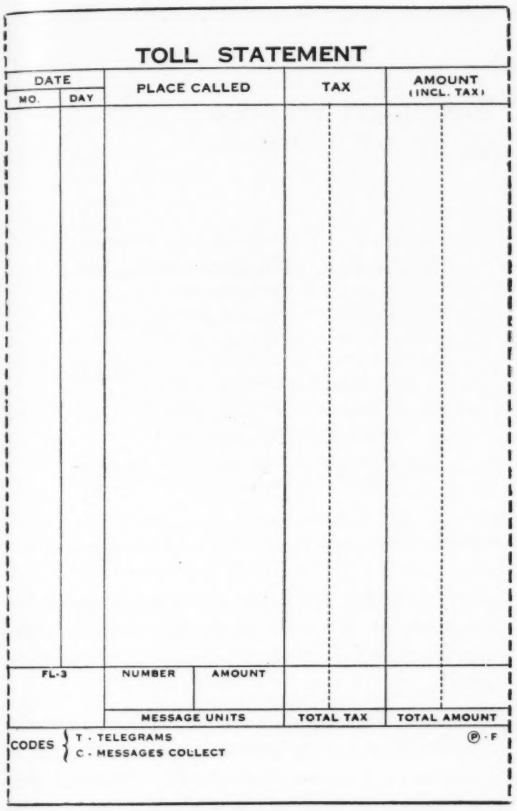

Figure 14. Toll Statement.

change service charges, directory advertising charges, move and change charges, service connection charges, construction charges, previous balances and credits to produce the final, total bill for presentation to the subscriber along with his detailed toll statement. A summary punch machine operating in coordination and simultaneously with the printing tabulator prepares a tabulating card automatically, showing the totals on each toll statement for use in compiling the subscriber bill. Figure 16 illustrates this toll statement summary card. Using manual key punch methods for keeping the master file of exchange service tabulating cards current in respect to the other aforementioned items these and the toll statement summary cards are merged by subscriber number through automatic sorting. The processing of the resulting file of tabulating cards for each subscriber number in the given exchange, all set up on the form of tabulating card illustrated in Figure 16, results in the printing of a final customer bill in the form illustrated in Figure 17. These general bills are manually associated with the respective toll statements and placed in the mail for collection.

Control accounting on the general subscriber bill is accomplished by the use of register sheet forms mechanically listed and totaled in the style illustrated by Figure 18. Customer collections are posted daily in the right hand margins of these control sheets with customer credits, previous balances, delinquencies and the credit status of each account emerging from the process. At the same time the general ledger postings and other accounting data are accumulated from the footings on the respective columns of the control.

Procedure Charts A, B, and C illustrate the entire billing process reviewed in the aforementioned discussions and show the detail and continuity of the respective operations. Some of the IBM equipment employed for these operations in the Sunland exchange is shown in Figures 19 and 20.

Economics of Accounting Selections

The conclusions reached in designing the Sunland accounting plan and the recommendations contained in the foregoing discussion of accounting operating procedures should not be misconstrued as a general argument for this type of operation in all metropolitan area exchanges or all metropolitan area telephone companies. In the single exchange operation of Sunland-Tujunga Telephone Company it is significant in the selection of accounting methods that 81.2% of the total tickets to be billed in the exchange fall within the *subscriber* dialing range and accordingly lend themselves to automatic interpretation by unattended tape-to-card key punches; 18.8% of the outward calls fall in the operator dialing range with only 5.1% requiring manual key punching and 13.7% comprising coin box tickets on coin collections and requiring no key punching or billing. Table IV, herein, details the segregation of tickets between automatic and manual key punch operation.

If the percentage of tickets falling within the subscriber dialing range were materially reduced the advantages of automatic key punching would be correspondingly reduced. Many, if not most, multi-exchange telephone companies operating

Table IV

SEGREGATION AUTOMATIC VS. MANUAL KEY PUNCHING

August, 1949

	Class of Tickets	Automatic Key Punch	Manual Key Punch	Not Billed Memo Tickets
1.	Subscriber "message unit" calls	27,896		
2.	Subscriber AB "station" calls	34,761		
3.	Interexchange Rec. Service calls (billed to called party)		1,258	
4.	AB Coin Box calls			10,528
5.	Incoming "collect" calls from Metropolitan Area		547	
6.	Outgoing "person" calls to Metropolitan Area		249	
7.	Long Distance calls		1,903	
	Totals	62,657	3,957	10,528
	% to total of 77,142	81.2	5.1	13.7

some exchanges in metropolitan areas and many others outside of metropolitan areas with a single centralized revenue accounting and billing office may find the ratio of calls falling within the automatic ticketed, subscriber dialing range reversed in relationship to total toll tickets to be billed. If this is the case it is possible that the economic advantages of manual billing procedures or of processes other than automatic key punch operation will be controlling and the economic argument may lie wholly in favor of other methods.

Relative annual charges of manual operation vs. machine operation in the Sunland office are tabulated in Table V with the final result showing an advantage of $4,000 per year of operation savings in favor of the mechanical methods ($16,080 per year for manual billing as against $12,080 per year for machine billing).

Directory and Information Practices

The increasing of direct subscriber dialing access to encompass many exchanges, as contrasted to a single exchange or closely clustered group of exchanges, creates the problem for the operating telephone utility of supplying telephone number directory and information service for the entire enlarged area. It could well be that the advantages of direct-dialed, station to station handling of calls could be offset and the purpose of such service partially defeated if measures are not taken to supply sufficient telephone number information at the subscriber's premises to avoid congestion on information boards and information circuits.

In many metropolitan area telephone networks a common directory covering the entire area is available or a group of directories arranged geographically, as in the case of the Los Angeles Metropolitan Network, can be obtained. In the event, however, a single exchange or group of exchanges contemplates automatic toll ticketing operations and at the same time is publishing its own directory for a restricted segment of the metropolitan area the necessity for merging the smaller directory with a directory of the overall area or of obtaining other "foreign" directories covering much of the area within the subscriber dialing range becomes a major consideration. However, a subscriber's requirement for directory information being a product of his own individual usage it may be neither economical nor physically practical from a delivery standpoint to make available to *all* subscribers in a given exchange a complete directory. Individual calling habits and expressed requirements by the subscribers themselves over a period of time in advance of the conversion to direct subscriber dialing and automatic toll ticketing give practical clues as to the optimum directory distribution plan.

In the instance of the Sunland Exchange the

Table V

Comparative Annual Costs

PRINT TICKET BILLING VS. PUNCH TICKET BILLING

		Print Ticket (man-years)	Punch Ticket (man-years)
Annual Payroll Comparison			
1. Rating subscriber dialed calls			0.03
2. Rating operator dialed calls		0.10	0.10
3. Sorting subscriber dialed calls		0.50	0.10
4. Sorting operator dialed calls		0.05	0.01
5. Listing subscriber dialed calls		2.00	0.50
6. Listing operator dialed calls		0.30	0.30
7. Summation subscriber and operator calls		0.20	0.05
8. Accounts Receivable Ledger		0.10	0.01
Total man-years		3.25	1.10
Cost @ $2700		$8,780.00	$2,970.00
Fixed Charges and Maintenance on additional Central Office Equipment to provide printing and rating features for printed ticket operation ($30,000 @ 18.4% per year)		5,520.00	
Fixed Charges on Accounting Machines to interpret printed tickets			
Depreciation @	10.0%		
Property Taxes @	2.4		
Insurance and Protection @	1.0		
Interest and Earnings @	7.0		
Maintenance Services @	5.0		
Total of $7,000 investment @	25.4%	1,780.00	
Rental of IBM Key Punch Equipment to interpret Tape Tickets			
1 031 Manual Key Punch	300.00		
2 042 Automatic Key Punch	1,440.00		
1 082 Model 1 Sorter	720.00		
1 405 Tabulator	2,520.00		
1 921 Automatic Carriage	240.00		
1 517 Summary Punch	780.00		
	6,000.00		
Excise Tax @ 10%	600.00		
	6,600.00		6,600.00
Key Punch Tabulating Card Stationery (1500M @ 1.25)			1,875.00
Fixed Charges on $2500 investment in files, racks, freight, etc. for key punch operation @ 25.4%			635.00
Total Annual Charges		$16,080.00	$12,080.00

location of the exchange and the calling habits of residents of the area recommended a single directory book in which all Sunland residence and business listings were merged alphabetically with all other similar listings for 8 other exchanges, all located in the Northwestern Section of the Los Angeles Metropolitan Area. All subscribers receive this one directory and about 20% of the total subscribers, including a majority of the business users, were supplied, in addition, the directory for the Central, downtown, metropolitan district. Certain other special requirements were met by

TELEPHONE NUMBER	TOLL CHARGES	TELEGRAM CHARGES	NUMBER MESSAGE UNITS	M. U. CHARGES	TOTAL TAXES	TOTAL AMOUNT

Figure 15. Toll Register Sheet.

delivering Western Area directories, Southwestern Area directories and Northeastern Area directories to specific subscribers where usage needs created the demand. Although the introduction of Automatic Toll Ticketing operations in the Sunland Exchange did not create substantial new directory cost considerations it is impractical to generalize from the experience of Sunland or any given exchange on the possible effect upon directory cost of the application of direct subscriber toll dial-

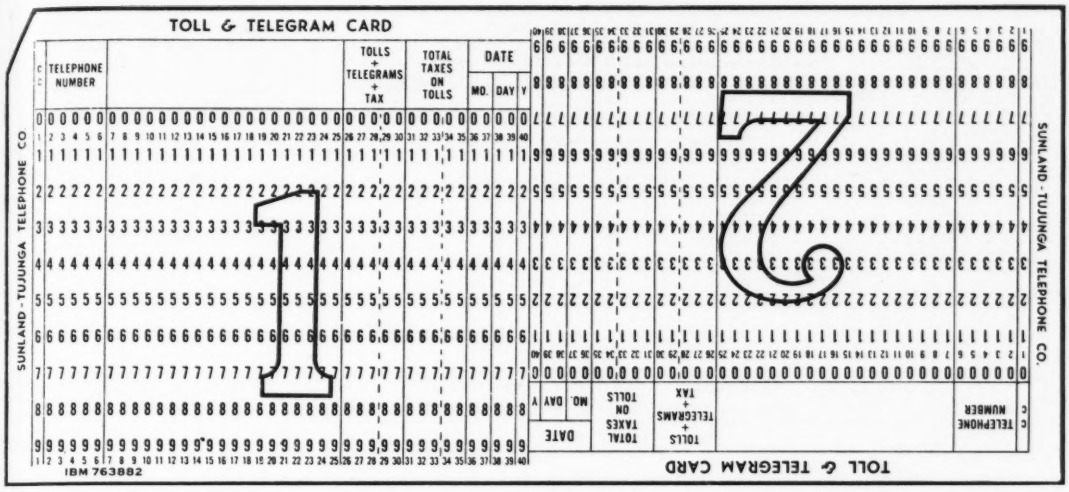

Figure 16. Toll and Telegram Card.

ing; the subject deserves specific review in the light of its economic effect as one of the factors which may argue either pro or con for the introduction of automatic operation, depending upon local circumstances and established directory policies.

It is necessary in planning information pages for the telephone directories to be used under direct subscriber dialing conditions to cover special dialing instructions and precautions peculiar to automatic toll ticketing operation. Telephone companies may differ in their policies with respect to certain traffic handling features; without going into the various alternatives available in regard to each directory instruction the scope of subject matter which should be included in any directory outlining automatic toll ticketing procedures is as follows:

1. A list of all exchanges and associated prefix codes available to direct subscriber dialing.

2. Instructions for obtaining the immediate quotation of charges on toll calls placed when such quotations are required. (In Sunland request is made that quotation calls be placed through the DS"A" or "O" operator.)

3. Instructions on procedures for obtaining credit on wrong numbers reached (any call completed by automatic toll ticketing operation, even those to a wrong number, will record a toll ticket and charge for the initial period of three minutes).

While none of the essential services available under operator control of toll traffic need be denied a subscriber because of conversion to SATT operation the placing of direct dialing access in the hands of the telephone subscriber without the trained supervision characteristic of switchboard handling may result in embarrassments and unjustified costs both to the subscriber and to the telephone utility. Carefully planned telephone directories and information procedures supply training for the subscriber and serve as a governor or safety valve on lack of dialing experience or error on the subscriber's part.

Collections and Customer Contacts

Generally speaking automatic toll ticketing operation not only pleases the public in respect to the speed and convenience of handling his telephone calling but may be expected also to simplify and render more efficient the commercial office contacts associated with collections.

The toll ticket, toll statement and subscriber bill illustrated in Figures 13, 14 and 17 are in themselves a precise and legible accounting to the subscriber, rendering adequate proof of charges and making possible ultimate efficiencies in filing and in finding records of toll usage. The control ledger illustrated in Figure 18 is equally effective in establishing the validity of charges of telephone users. Mechanization throughout the process of record-

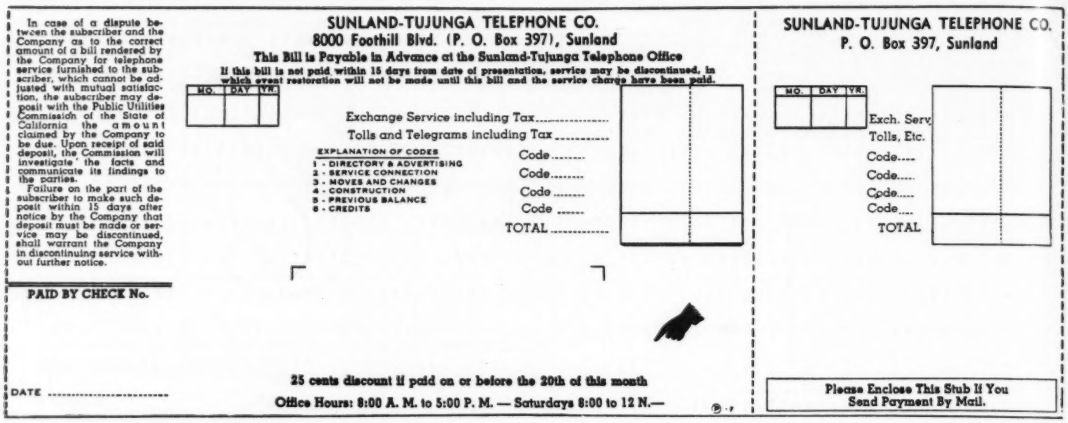
In case of a dispute between the subscriber and the Company as to the correct amount of a bill rendered by the Company for telephone service furnished to the subscriber, which cannot be adjusted with mutual satisfaction, the subscriber may deposit with the Public Utilities Commission of the State of California the amount claimed by the Company to be due. Upon receipt of said deposit, the Commission will investigate the facts and communicate its findings to the parties.
Failure on the part of the subscriber to make such deposit within 15 days after notice by the Company that deposit must be made or service may be discontinued, shall warrant the Company in discontinuing service without further notice.
PAID BY CHECK No.
DATE
SUNLAND-TUJUNGA TELEPHONE CO.
8000 Foothill Blvd. (P. O. Box 397), Sunland
This Bill is Payable in Advance at the Sunland-Tujunga Telephone Office
If this bill is not paid within 15 days from date of presentation, service may be discontinued, in which event restoration will not be made until this bill and the service charge have been paid.
MO. DAY YR.
Exchange Service including Tax
Tolls and Telegrams including Tax
EXPLANATION OF CODES
1 - DIRECTORY & ADVERTISING
2 - SERVICE CONNECTION
3 - MOVES AND CHANGES
4 - CONSTRUCTION
5 - PREVIOUS BALANCE
6 - CREDITS
Code
Code
Code
Code
TOTAL
25 cents discount if paid on or before the 20th of this month
Office Hours: 8:00 A. M. to 5:00 P. M. — Saturdays 8:00 to 12 N.—
SUNLAND-TUJUNGA TELEPHONE CO.
P. O. Box 397, Sunland
MO. DAY YR.
Exch. Serv.
Tolls, Etc.
Code
Code
Code
Code
TOTAL
Please Enclose This Stub If You Send Payment By Mail.

Figure 17. Subscriber's Telephone Bill.

ing and billing permits the attainment of a higher degree of precision and neatness than can ordinarily be accomplished with operator-written toll records. The result is favorable and popular from a commercial standpoint.

Usage Stimulation and Circuit Holding Times

To date experience under direct subscriber toll dialing is not sufficiently extensive to evaluate the composite effect upon toll circuit quantity requirements and upon subscriber grading. There are several conflicting influences and as automatic toll ticketing operation expands to more and more exchanges throughout a metropolitan network a cumulative effect may be felt which would render conclusions drawn on the basis of a single exchange operation inaccurate.

Two general facts are obvious from measured experience: (1) the elimination of operator handling and switchboard contact in the completion of a toll call reduces circuit holding times and speeds the carrying of traffic; and (2) the same factors have a stimulating effect upon subscriber usage, increasing calling volume. Whereas the first of these would argue for a reduction in quantity of toll circuits the second tends to work in the other direction by increasing calling volume and possibly also increasing conversation time and general telephone usage habits. Since conversation time averages three to six or seven times greater than operating time on toll traffic the stimulation of calling volume doubtless outweighs the operating time saving and the final result is to demand heavier toll trunking. Higher calling volume tends also to aggravate party-line conflict and stimulate demand for upgrading service to individual lines, thus requiring earlier reinforcement of exchange plant facilities. Rate structures would control the cost-revenue relationship under these circumstances. Generally speaking rate structures are so designed as to render high grade service and high calling volumes compensatory.

As stated above, the expansion of automatic toll ticketing operation to more and more exchanges throughout a telephone network will result in feeling the combined effect of reduced circuit holding times and increased calling volumes on both-way traffic over circuit groups leading in and out of a given exchange. If plant expansion keeps pace with calling volumes, to permit efficient and uncongested traffic flow, advantages accrue to each exchange in the metropolitan network as other exchanges are converted.

Influence Upon Rate Structures

Mechanization of toll ticketing and toll accounting promises in the future to parallel the history of local automatic operation in its effect upon basic metropolitan area rate structures. Flat rate extended service plans in Metropolitan networks were an outgrowth of programmed operator work load reduction on local switchboards. It resulted from the physical and economic feasibility of extending direct dialing access to other adjacent exchanges. Similarly automatic toll switching and timing introduces for speculation the question of

	MISCELLANEOUS		PREVIOUS BALANCE	CREDIT	EXCHANGE RENTAL	TAX ON RENTAL	TOLL CHARGES	TAX ON TOLL	DIRECTORY ADVERTISING	TOTAL BILL	TELEPHONE NUMBER	DATE	AMOUNT PAID	ALLOWANCES	BALANCE DUE

Figure 18. Accounts Receivable Register Sheet.

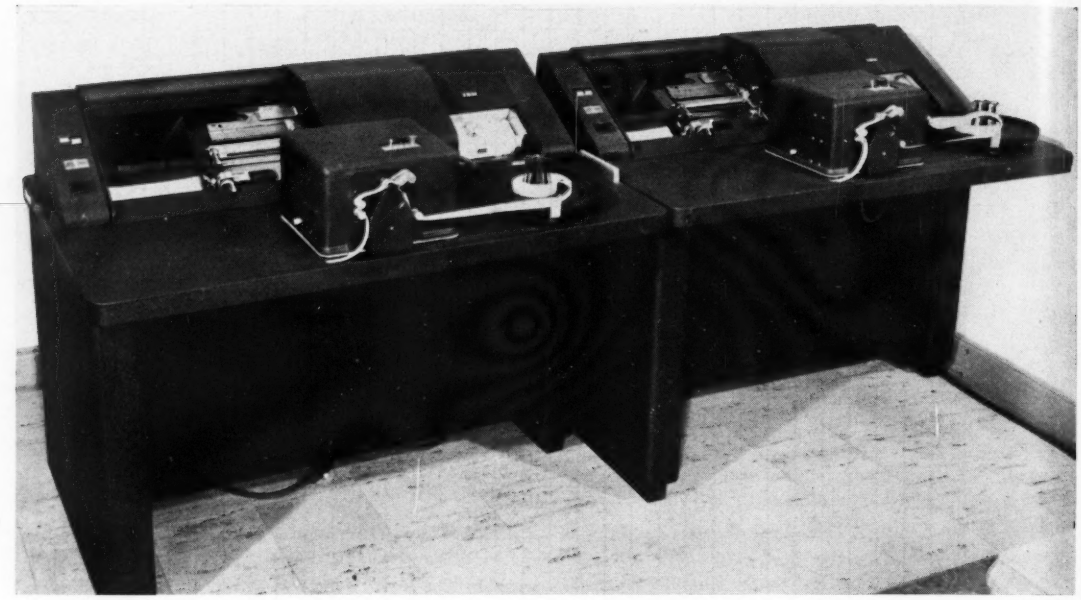

Figure 19. Two Type 042 IBM Automatic Key Punches for Decoding Perforated Tapes.

Figure 20. Left to right: Type 405 IBM Printing Tabulator, Type 517 IBM Summary Punch and Type 082 IBM Electronic Sorter.

how far this solution of the call-timing problem on *all* routes in the expanded subscriber dialing range may go toward improvement of rate structures. Both simplicity and economy may be served by requiring all subscribers to pay the same flat-rate and have the same, limited free calling access as well as benefit equally on fully measured (count, time and distance) usage by enjoying the minimum compensatory short haul toll rates.

The rate theorist finds himself in the same dilemma in tampering with the message-minute-mile unit of telephone cost measurement as the economic theorist when tampering with the basic rules of supply and demand. Classic discrimination or waste are the inevitable results. The limitations and discrimination of flat rate plans, which ignore usage volumes, are obvious; the low volume user is penalized to underwrite the costs of providing equipment and service for the high volume user who, in turn, is getting excessive value for his charges. Message-rate plans inject equity to a certain degree by measuring relative message volume but even here a two-*hour* message is weighted equally with a two-*minute* message. The absolute and non-discriminatory measurement requires that the usage time and calling distance factors be fully considered. Therein lies a fundamental need for perfecting automatic toll ticketing procedures; the basic rate objectives of reconciling the *value* of service to the subscriber and the *costs* of rendering the service are more nearly approached with each advance toward the solution of the timed usage problem. The capacity of SATT equipment for full identification of four-party subscribers, as well as one-party and two-party subscribers, almost completely encompasses Metropolitan and Suburban grades of service and introduces the unprecedented rate feature of accurately measuring *all* interexchange calling volume, distance and timing without impairing speed of dialing or involving operator performance.

Prospects of Increasing Subscriber Toll Dialing Development

Rapid continuing progress by The Pacific Telephone and Telegraph Company in expanding subscriber toll dialing development for extended service subscribers throughout the Los Angeles Metropolitan Area evidences that this region has been a successful proving ground for the Bell System type of equipment.

Independent telephone companies operating exchanges in the Los Angeles Area and adjacent to the city of Chicago have factory engineering plans well in progress for the conversion to Automatic Toll Ticketing and direct subscriber dialing (but possibly with varying degrees of application to the telephone commercial development in the respective exchanges) at Des Plaines, Illinois; Park Ridge, Illinois; Monrovia, California; Santa Monica, California and West Los Angeles, California. These projects are scheduled tentatively for completion during the next one to three years in the approximate order listed. Other Independent telephone exchanges operating adjacent to major metropolitan networks, particularly in the Los Angeles, San Francisco, Seattle and Portland areas on the Pacific Coast, have this type of operation under appraisal on a "study basis" with prospects that technological and economic considerations may recommend the adoption of automatic toll ticketing plans.

Although Automatic Electric Company, Chicago, Illinois is the sole source of automatic toll ticketing equipment in the Independent market at the present time there are indications that other Independent manufacturers are working on future developments along the same line.

Extension of Automatic Toll Accounting Beyond Metropolitan Networks

It is too early to foresee the extent of ultimate expansion of Automatic Toll Switching and Automatic Toll Accounting operation to include traffic in the operator dialing range and beyond metropolitan networks. This probability is apparent, however, as the equipment installed at Sunland possesses the inherent technical ability and properties to offer this feature. The economic and physical problems incident to "Automatic Toll Board Ticketing", as this feature may be named, depend upon traffic calling volumes and availability of direct dialing routes to a given toll center or toll operating switchboard; it is, further, a function of relative costs of manual ticketing as against automatic tape ticketing. It is possible, therefore, to discuss automatic toll board ticketing at this date on a laboratory basis only. With this qualification the operating procedure contem-

plated by automatic toll board ticketing would have the following features:

1. To reach those routes accessible through Automatic Toll Board Ticketing a special code (possibly "211" or some appropriate special service code) would be dialed by the subscriber thus bringing into operation the same identifying equipment as will be used for the regular Automatic Toll Ticketing on subscriber dialed traffic.

2. Upon receiving the request for a called number available to the Automatic Toll Board equipment the operator would set up fourteen digits on her key sender. The first ten of these digits would supply the routing information to the called exchange; the last four digits would supply the rate information, which the operator will have obtained from her switchboard bulletin, thus supplying the initial period rate for the call to the distant exchange.

3. After setting up the fourteen digits for routing and rate information, all in a single operation, the operator would listen on the line until the called party answered at which moment she would depress a "start key" signaling the equipment to commence timing. Supervision of the remainder of the call would be entirely automatic with the timing controlled by the calling subscriber's switch hook.

Looking to the future, this hypothesis of extending automatic toll accounting into the operator dialing range appears to be a logical supplement to subscriber-dialed automatic toll accounting. It also offers for speculation the possibility that the mechanization of toll offices even outside of metropolitan networks may result in economies and permit taking advantage of punched tape billing in revenue accounting offices.

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PROCEDURE CHART

APPLICATION

COMPANY Sunland-Tujunga Telephone Co.

OPR.	DESCRIPTION
1.	Mechanically punch Toll Cards from tape.
2.	Sort Toll Cards to Class of Service.
3.	Sort Local Service Cards to Exchange Called including Master Cards.
4.	Gang Punch into Local Service Cards Alphabetic characters, in abbreviation, of Exchange Called.
5.	Sort to separate Local Service and Master Cards.
6.	Sort Local Service and Extended Service Cards to Rate and Minutes including Master Cards.
7.	Gang Punch into Local Service Cards extension of Rate X Minutes = Tax - Amount - Amount + Tax.
7-1	Gang Punch into Extended Service Cards extension of Rate X Minutes = Message Units - Tax - Amount - Amount + Tax.
8.	Sort out Master Cards.
9.	Sort for Cycle.
10.	Tabulate by Cycle for control purposes.

DATE

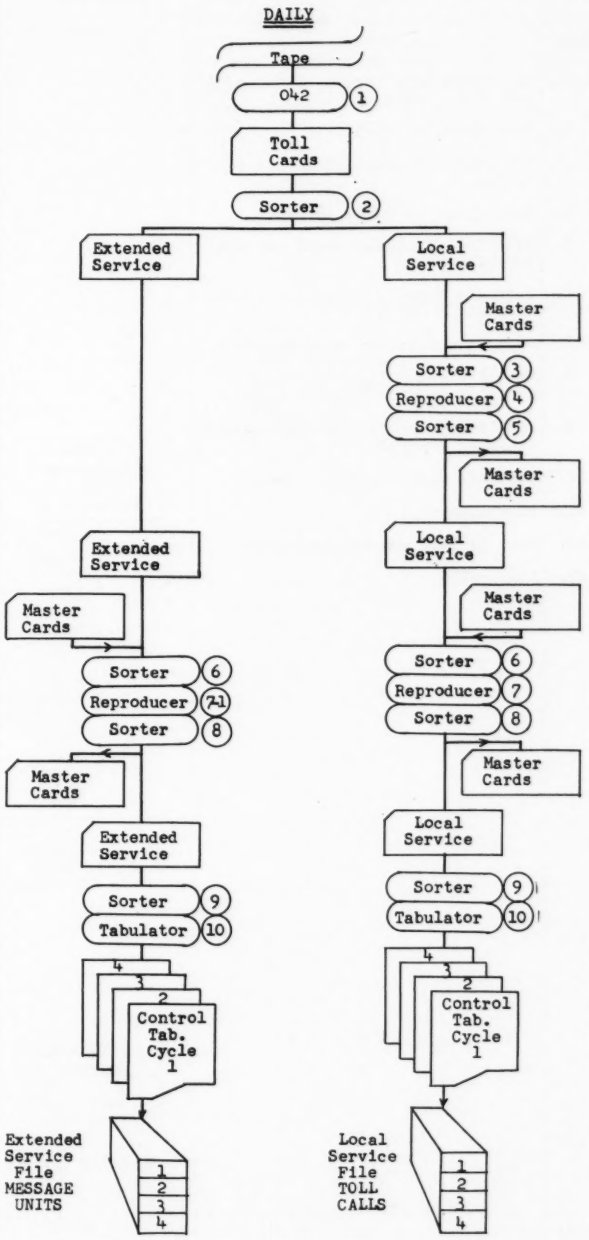

Chart A.

PROCEDURE CHART

APPLICATION

COMPANY Sunland-Tujunga Telephone Co.

OPR.	DESCRIPTION
1.	Key Punch Long Distance, Telegram and Item Cards.
2.	Sort Cards to Cycle.
3.	Tabulate and post totals for controls.
4.	Sort Cards to Phone Number.
5.	List Toll Statements and cut Summary Cards.
6.	Tabulate Summary Cards and balance to Daily Controls.
7.	Sort Item Cards to Item Sequence.
8.	Tabulate and balance to Daily Controls and cut Summary Cards.
9.	Tabulate Summary Cards and balance to Daily Controls.
10.	Sort all Cards on Phone Number.
11.	List Register.
12.	Sort in Name and Address Cards.
13.	List Bills.

DATE

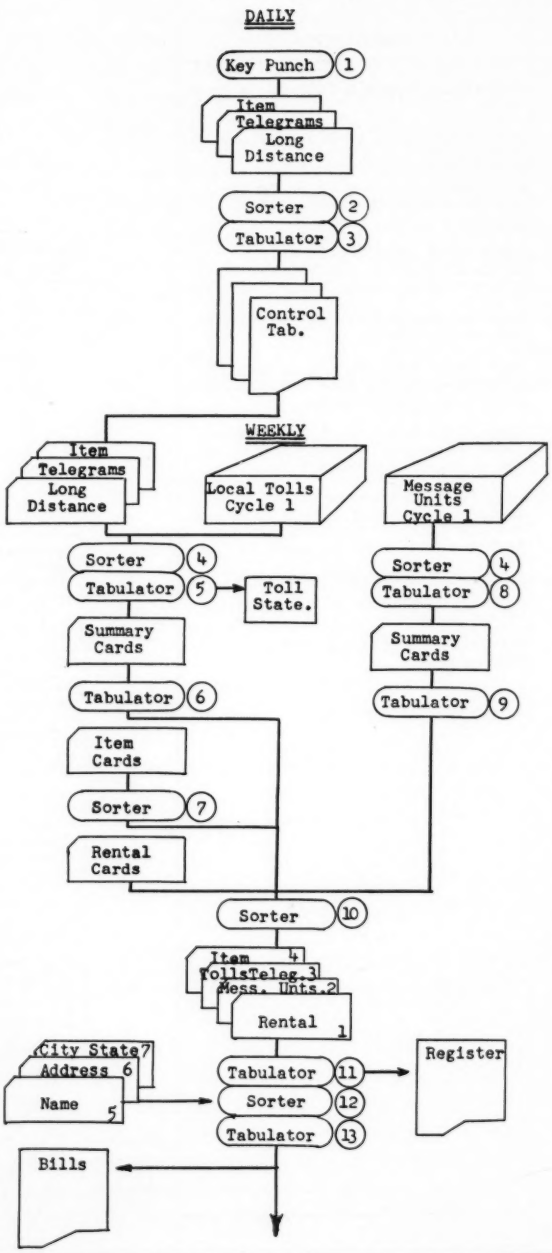

Chart B.

PROCEDURE CHART

APPLICATION

COMPANY Sunland-Tujunga Telephone Co.

OPR.	DESCRIPTION
14.	Sort out Name and Address Cards.
15.	Sort Cards to Card Code.
16.	List separate Journals for each Card Code group of cards.
17.	Sort Cards to Item Code.
18.	List separate Journals for each Item Code group of cards.

DATE

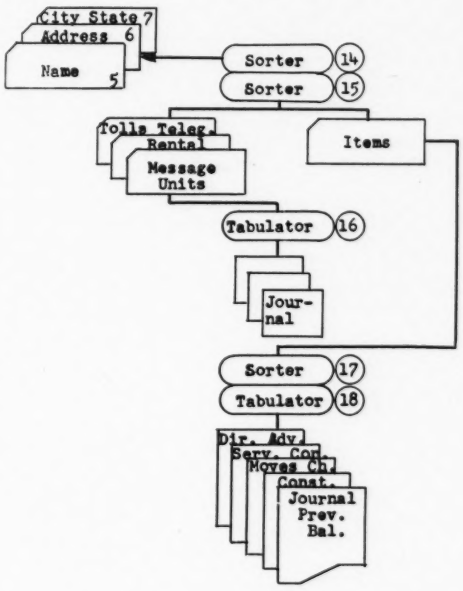

Chart C.